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SCHOOL SCIENCE AND MATHEMATICS

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The Chemical Bond Approach to Introductory Chemistry*

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The beginnings of the CBA Project lie in a paper published in the *Journal of Chemical Education* in 1958 by Laurence E. Strong and M. Kent Wilson. This paper was an outgrowth of a conference in June, 1957, at Reed College in Portland, Oregon. The conference was attended by high school and college teachers of chemistry: its purpose was to discuss the integration of high school and college chemistry courses. (This conference was sponsored by the Crown-Zellerbach Foundation.) The actual development of course materials for introductory chemistry was begun in the summer of 1959 in a writing conference at Reed College, sponsored by the National Science Foundation. Nine college teachers of chemistry and nine high school teachers attended this conference, and they have constituted the nucleus of the project since that time.

The initial materials consisted of 18 chapters of text and 20 experiments. These were tested by use in 9 high schools during 1959–60. Several classes were composed of students selected on the basis of mental ability, but others were composed of average high school chemistry students. While an initial reaction of some persons who looked at the materials was "You can't teach this to high school students," the results of the first year's trial showed that the materials *could* be taught to high school students. The materials have been (and are being) revised for further testing in 1960–61 in 75 high schools throughout the country.

* Paper presented at the annual CASMT convention, Detroit, Michigan, November 24–26, 1960.

So much for a brief history of the project. Anyone interested in more of the historical details can read them in *Supplementary Readings for Chemical Bond Approach*, a collection of reprints from the *Journal of Chemical Education*. What we are more interested in here is what the course is like and how well it is working in schools.

Nature of the CBA Text Materials

A recent booklet** written by O. T. Benfey begins "It is common knowledge that chemists have their toys." The toys of CBA consist of a variety of models, some physical and some mental, which attempt to explain observed phenomena. (We will take a look at some of these models later.) As a matter of fact, the major course emphasis is upon attempts to utilize ideas to relate various aspects of chemical behavior to one another. The ideas, and their testing and application, are considered more important than recall of the specific behaviors which they relate. Thus, as many students have discovered to their joy (and others to their horror), CBA is more prominently a thinking course than a memory course.

The *emphasis* is upon ideas, and the *theme* of the ideas discussed is chemical bonding. It will be obvious that to follow this theme consistently the course must omit a considerable body of material that has traditionally been included in introductory chemistry. Few industrial processes are of use in developing ideas related to bonding. The specific properties of metals, and of families of metals, are important only in so far as they contribute to ideas about the metallic bond. The nucleus of an atom, except as its positive charge helps determine atomic structure, is not important in development of bonding ideas. Consequently, nearly half of the material presently found in introductory chemistry text books has been left out of the CBA course.

On the other hand, the development of ideas of any reasonable adequacy concerning covalent, ionic, and metallic bonds—and intermediate types—requires the use of some material which was formerly thought to be "difficult" even at advanced college levels. Ask a simple question, such as, "Why does HCl react with H_2O?" To get an answer the student must consider the structures of the two molecules and the forces acting to hold them individually together. He must have an idea of the *shapes* of the molecules, and to obtain such an idea he must have some mental model regarding atomic and molecular structure in general. The *bent* H_2O structure is not predicted by the usual concepts dealt with in introductory chemistry. Thus the orbital model is an essential part of the course. (Actually the orbital model is preceded in the course by a simpler cloud model based on gratuitous assumptions.)

** *From Vital Force to Structural Formulas*, 1959.

Ask other questions: How can diamond and graphite be the same chemical? Why is water liquid at room temperature while its constituent elements are gases? Why is there an apparent limit of atoms of oxygen that can be attached to one carbon atom—CO, CO_2, CO_3, but not CO_4? The answers are all related to structure, and a major part of the CBA course is devoted to developing architectural ideas.

After some introductory material designed to raise a lot of questions and inspire curiosity, a brief foundation is laid related to the electrical nature of matter. Then the first of two structural models is begun. Prior to this time the students have done an experiment with the "black box." This is simply a box containing some object whose *nature* is to be ascertained without opening the box. By appropriate devices (tilting, shaking, sniffing, weighing, etc.) the student obtains data concerning the object. He then constructs a mental model of the object and tests the model by observing whether predictions based on it hold true. Now the student is asked to accept certain assumptions about electrons and protons, to build a model of atomic structure based on these assumptions, and to test the model by asking questions of it.** This model, and the "black box" experiment are used deliberately to impress upon the student that science is manmade, not divinely revealed.

Ideas of covalent bonding are largely developed through use of this model. When it is seen that energies, as well as spatial relationships, are important in explaining chemical behavior, the orbital model is developed. Following a discussion of energy relationships, with emphasis on free energy, metallic and ionic bonds are considered. Associated with this latter development is consideration of the periodic nature of the properties of elements. Acid and base behavior, as a specific example of energy and concentration relationships, is discussed (in Chapter XIV). Finally, the relatively complicated chemistry of water is dealt with.

The close of the course may consist of three possible alternatives—a section in which the concepts developed are applied to selected organic systems (the OH group in various environments), a section which raises further questions not considered in the course (a transition into more advanced chemistry courses), and a laboratory study.

Nature of the CBA Laboratory

Since chemistry is an experimental science, the development of the laboratory portion of the CBA course has been considered of vital importance. The purposes of the laboratory have been stated as the exploration of ideas, the utilization of experimental data, and the promotion of independent experimentation.

** See Chapters IV and VI of *Chemistry*, Volume One—Second Edition (CBA text).

It was felt that if these ambitions were to be, even partly, realized the experiments would have to be designed and carried out by the students themselves. Most students, however, cannot do this at the beginning of the course: they must be trained in this as in other skills. Consequently, the laboratory manual contains three kinds of experiments. The first ten contain fairly specific directions (experiment 2, "Measure 3 ml. of substance 'A' into a Pyrex test tube.," etc.). But the student is encouraged to record all observations, not only those which would answer specific questions or fill blanks (experiment 2, "Record in your notebook all changes observed when substance 'A' was mixed with substance '1' ").

Even though general directions are fairly specific in this first group of experiments, not all procedures are given in detail and some are not given at all. In experiment 4, on the reaction of methane and oxygen, the final direction is, "Record in your notebook observations such as the color, size, shape and approximate temperature of the flames. Also include any information obtained as to the products formed when an air-gas mixture is burned." Nothing is said about *how* to determine temperatures in a flame or *how* to identify products. The idea is that the teacher and class together will discuss the problem and propose ways of attacking it. To make this of real value the teacher must be willing to let students try their proposed procedures (as long as this can be done safely) even though he may feel sure they will not work.

A good illustration that this can be very effective was furnished by a report from one of the teachers in the project this year. The Student Guide to experiment 9, Diffusion—Effusion, consists of the following:

Part I

Determine the relative rates of diffusion of $HCl_{(g)}$ and $NH_{3(g)}$ and compare the ratio of the relative rates of diffusion to the molecular weights of the two gases.

Part II

Determine the relationship between the molecular weight and the rate of effusion of a gas.

The teacher in this case and his class discussed possible means of collecting pertinent data. Many suggestions were made by students and each was evaluated by the group. Finally several ideas were accepted as worth trying experimentally. (The teacher did not make any of these suggestions.) These procedures were then followed in the laboratory and the data were discussed by the class. The teacher reported that the students whose ideas had failed to yield usuable data felt somewhat frustrated but the whole class learned a valuable lesson on the nature of science.

When one looks at the materials it will be noticed that, with two exceptions, the first ten (directed) experiments are also fairly traditional in content. The second and third types are quite different on both points. In the second group of experiments, suggestions are given only to help the student to "get a start" in a useful direction toward solving the problem, and in the third group only the problem is given —no directions. The content also becomes more and more sophisticated. In one experiment the student is asked to determine the heat of formation of solid NH_4Cl. He can do this by combining some data given in the Guide with other data determined in the laboratory. In another experiment the student is asked to determine the relative polarities of three compounds.

Laboratory notes are kept in a blank notebook consisting of quarter-inch graph paper with alternate white and yellow sheets. The original notes, written *in the laboratory*, are made on the white sheets and a carbon copy on the yellow sheets. The copies are torn out and handed in for checking by the teacher, and the student keeps his original record. (During the trial program this year, the carbon copies are sent to the Laboratory Development Center for processing, evaluation of experiments, and use in redesigning experiments for the course revision.)

In contrast to the very brief student Guide, the Teacher's Guide to the laboratory is more voluminous. It contains a theoretical discussion of each experiment, background information that the teacher might find useful, and suggestions on possible pre- and post-lab discussions regarding the experiment. This guide also contains a major section on the general philosophy of the laboratory program, since it is important that the teacher understand the goals and the intended progressive development of experimental techniques. (Prominent in this philosophy is the idea of extensions—students are to be encouraged whenever possible to extend their investigations beyond the immediate experiment and to try to collect experimental data to answer problems which they have raised.)

Evaluation

Evaluation of the course materials is being made through weekly reports sent in by the teachers on text materials, teacher reports and student laboratory notes on each experiment, visits to schools in the program by CBA staff members, three series of regional meetings for small groups of teachers, and a test program. Through the various reports and meetings held so far much information has been collected which should be helpful in preparing the third edition of text and laboratory materials. The general finding is that these materials, much of them considered difficult by some teachers, can be taught to

beginning chemistry students. Students in average classes, as well as several groups of younger-than-usual chemistry students (sophomores), appear to be responding to the challenge which requires them to organize their ideas rather than to memorize details, and are doing better (in many cases) than one would expect.

An interesting finding made through the test program the first year, 1959–60, and one which parallels results obtained in the PSSC program, was that the correlation between achievement tests over CBA material and aptitude test scores is *lower* than the correlation between most other achievement tests and aptitude tests, and furthermore, the correlation decreases throughout the course.

On the most recent test given the final four or five questions were related to the structural model of atoms developed from assumptions stated in the text. The "gimmick" was that one of the assumptions was altered on the test questions, with the result that new models had to be constructed. All but a very few students have said that they enjoyed this part of the test *even though some of them did rather pocrly* as measured by correct answers.

This is a good summary of the student reaction to the course. Most of them like it even though a few may have difficulty and "do poorly." (It is respectfully suggested that the same students would also do poorly in a more traditional chemistry course, and that they probably *would not* like it.)

METEORS CALLED SPACE PROBE

Meteors, which cause "shooting stars" when burning up in the earth's atmosphere, are the "poor man's space probe," Dr. Edward Anders of the University of Chicago told the American Association for the Advancement of Science meeting last December.

From the viewpoint of learning about the nature of cosmic radiation, Dr. Anders said that a "meteorite is nothing but a 'poor man's space probe' that was launched quite unceremoniously somewhere in the asteroidal belt sometime during the last two billion years and was recovered recently without assistance from the Air Force."

He believes that asteroidal-size bodies were formed from primordial cosmic dust. These bodies underwent volcanic-like eruptions, cooled to sub-zero temperatures, collied with each other in space and broke up into meteroites.

The maximum size of these asteroids, parent bodies of meteorites, was not more than 300 miles in diameter. The asteroidal belt, birthplace of meteorites, is located between the oribits of Mars and Jupiter.

The parent bodies were formed early in the history of the solar system, four and a half to five billion years ago, Dr. Anders reported.

Many meteors come to violent deaths colliding with the earth. Several meteorites, meteors that survive their blazing journey through the atmosphere to reach the earth's surface, have been found to contain diamonds.

Meteorites, Dr. Anders said, offer clues to such fundamental questions as the origin and age of the chemical elements, the origin of life, the age of the earth, the relation between cosmic rays and the sun, and even such down-to-earth ones as "the wearing away of missile nose cones during passage through the atmosphere."

A Bibliography of Doctoral Dissertations Completed in Elementary and Secondary Mathematics from 1918 to 1952*

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This bibliography is a compilation of doctoral dissertations completed during the period 1918–1952. The bibliography is considered to be comprehensive, although undoubtedly some studies have been completed which do not appear in these sources. The sources used are:

1918–1927 *Ten Years of Educational Research*, 1918–1927, Walter S. Monroe, *et al.*, Bureau of Educational Research University of Illinois, Urbana, 1928 (Bulletin #42).

1926–1940 *Bibliography of Research Studies in Education*, Prepared in the Library Division, Office of Education, by Edith T. Wright with the cooperation of Ruth T. Gray, United States Department of the Interior, United States Government Printing Office, Washington.

1940–1952 *Research Studies in Education, A Subject Index of Doctoral Dissertations, Reports, and Field Studies*, Mary Louise Lyda and Stanley B. Brown, Boulder, Colorado, 1953.

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History and Textbooks

1. "American Culture as Reflected in Mathematical Schoolbooks," Rachel Francelia Hinckeley, Columbia University, 1950.
2. "The Selection of Certain Significant Concepts in Algebra and the Determination of Their Degree of Emphasis in Widely Adopted Texts," Truman L. Koehler, University of Pennsylvania, 1952.
3. "Historical Reasons Advanced for the Teaching of Geometry," Harry G. Kaplan, New York University, 1927.
4. "The Development of Informal Geometry," Robert Coleman, Jr., Columbia University, 1942.
5. "The History and Significance of Certain Standard Problems in Algebra," Vera Sanford, Teachers College, Columbia University, 1927.
6. "Changes in the Content of Elementary Algebra Since the Beginning of the High School Movement as Revealed by the Textbooks of the Period," Amy Olive Chateauneuf, University of Pennsylvania, 1929.
7. "Important Educational Factors Conditioning Secondary School Mathematics in the United States Since 1890," Ruth Ripley, Yale University, 1947.
8. "Evolution of Algebra as a Secondary School Subject," Willis L. Pickard, George Peabody College for Teachers, 1948.

* This is the first of two articles listing dissertations in mathematics education. The listing covering the period 1951–1960 will appear in the next issue.

9. "Introduction of Algebra into American Schools in the Eighteenth Century," L. G. Simons, Teachers College, Columbia University, 1925.
10. "A Historical Survey of Algebraic Methods of Approximating the Roots of Numerical Higher Equations up to the Year 1819," M. A. Nordgaard, Teachers College, Columbia University, 1922.
11. "The Influence of Thompson Simpson on the Progress and Development of Mathematics in England during the Century Following the Death of Newton," Frances Marguerite Clarke, Teachers College, Columbia University, 1928.
12. "The Algebra of Omar Khayyam," Daoud Suleiman Kasir, Teachers College, Columbia University, 1929.

Teacher Competencies

13. "The Status of Teachers and Teaching of Secondary School Mathematics in Texas for the Academic Year 1942–1943," Mary Edna Von Rosenberg, University of Texas, 1943.
14. "The Status of the Teaching of High School Mathematics in the State of Wisconsin," Lawrence F. Wahlstrom, University of Wisconsin, 1951.

Curriculum Development

15. "The Teaching of General Mathematics in the Secondary Schools of the U. S. A Study of the Development and Present Status of General Mathematics," Clarence McCormick, Teachers College, Columbia University, 1929.
16. "Trends in Elementary and Secondary School Mathematics 1918–1948," Jack D. Wilson, Stanford University, 1950.
17. "A Tentative List of Objectives in the Teaching of Junior High School Mathematics, with Investigations for the Determining of Their Validity," Raleigh Schorling, Teachers College, Columbia University, 1925.
18. "A Critical Examination and Experimental Reconstruction of Secondary School Mathematics," E. R. Breslich, University of Chicago, 1926.
19. "Functional Units of Instruction in Senior Mathematics," J. Wilmot McClimans, George Peabody College for Teachers, 1940.
20. "The Function of Mathematics in a State Educational Program," James Thomas Carr Wright, George Peabody College for Teachers, 1938.
21. "The Conflict Between the Theoretical and the Practical in Mathematics and Mathematics Teaching," Claude Harold Brown, University of Kansas, 1940.
22. "Philosophies of Education: Their Implications for Mathematics Curricula and Classroom Procedures," Abdel Aziz E. Ibrahim, Ohio State University, 1949.
23. "The Organization of Instruction in Arithmetic and Basic Mathematics in Selected Secondary Schools," Amanda L. Irvin, University of Southern California, 1952.
24. "Contributions of Mathematics to a Proposal for Reorganizing General Education in Secondary Schools on the Basis of a Core Program," Elsie J. Stalzer, Ohio State University, 1952.
25. "New Objectives for Ninth Grade Mathematics," William Madeira Willets, Temple University, 1944.
26. "Changing Philosophy and Content in Tenth Year Mathematics," Julius Hayman Hlavaty, Columbia University, 1950.
27. "A Study of Grade Placement of Socially Significant Arithmetic Problems in the High School Curriculum," Wesley John Lyda, Indiana University, 1943.
28. "A Synthesis and Evaluation of Subject-Matter Topics in Mathematics for General Education," Lauren G. Woodby, University of Michigan, 1952.
29. "Motivation in Mathematics: Its Theoretical Basis, Measurement, and Relationships with Other Factors," Enoch I. Sawin, University of Chicago, 1951.

30. "Significant Influences Affecting Geometry as a Secondary School Subject," Gustave H. Lundberg, George Peabody College for Teachers, 1952.
31. "Consumer Information in Eighth Grade Mathematics," Hubert B. Risinger, Rutgers University, 1949.
32. "The Place of the Elementary Calculus in the Senior High School Mathematics, and Suggestions for a Modern Presentation of the Subject," N. B. Rosenberger, Teachers College, Columbia University, 1921.
33. "A Course in the Calculus for Secondary Schools with New and Original Treatments of Many Topics Together with the Record of Seven High-School Classes in this Course," John A. Swenson, Teachers College, Columbia University, 1931.
34. "The Development and Evaluation of an Exploratory Course in Mathematics for Purposes of Educational Guidance in the Junior High School," Gerald Hamilton Ayers, University of Southern California, 1934.
35. "The Teaching Plan for the Unit of Work in Junior High School Mathematics," James Howard Zant, Teachers College, Columbia University, 1933.
36. "The Educational Possibilities of Geometry: A Theoretical Study Evaluating the High School Course in the Subject and Suggesting a Tentative Plan of Reorganization," Edward Russell Stabler, Howard University, 1935.
37. "The Commercial Mathematics Curriculum: A Validation of Some Basic Items," Walter F. Cassidy, Fordham University, 1940.
38. "Some of the Influences of the Requirements and Examinations of the College Entrance Examination Board on the Mathematics Requirements in the Secondary Schools of the U. S.," Leslie H. Whitcraft, Teachers College, Columbia University, 1932.
39. "A Plan for an Interscholastic Mathematics Contest in Westchester County," Kenneth Brown Morgan, Columbia University, 1947.
40. "Geometry of Repeating Design and Geometry of Design for High Schools," A. Day Bradley, Teachers College, Columbia University, 1932.
41. "A Study of Elements and Proofs of Plane Geometry," Francis Greenfield Lankford, Jr., University of Virginia, 1938.
42. "On the Class Number and Ideal Multiplication in a Rational Linear Associative Algebra," Carolyn Grace Shover, University of Ohio, 1932.
43. "An Analysis of Methods of Plane Curve Fitting," Joseph Henry Schotland, New York University, 1937.
44. "The Efficacy of Pupil Selection of Graded Originals in Plane Geometry," Ruth Onetta Lane, State University of Iowa, 1937.

Teaching Methods

45. "A Comparative Study of the Effectiveness of the 'Nature and Proof' and a Conventional Method of Teaching Plane Geometry," Chester Vincent Koppenhaver, Temple University, 1943.
46. "An Experimental Study to Determine the Relative Value of Two Methods of Teaching Mathematics on the Tenth Grade Level," William Sylvester Tobey, New York University, 1943.
47. "The Plane-Trace vs. the Edge-View System of Teaching Descriptive Geometry," Irwin Wladover, New York University, 1951.
48. "A Comparison of a Certain Type of Individual and a Certain Type of Group Instruction in 9th Grade Mathematics," C. N. Stokes, University of Minnesota, 1929.
49. "Measurable Outcomes of Two Methods of Teaching Experimental Geometry: A Controlled Experiment with Parallel Equated Groups to Determine Immediate and Remote Achievement of the Lecture-Demonstration and Individual-Laboratory Methods," David E. Brownman, New York University, 1938.
50. "Pupil-Centered Methods of Teaching Mathematics," Henry W. Syer, Harvard University, 1950.

51. "Group Process in Secondary School Mathematics," Lottchen Lipp Hunter, Columbia University, 1951.
52. "Recent Developments in the Teaching of Geometry," Jabir Shibli, Teachers College, Columbia University, 1932.
53. "A Study of an Individual Instruction Unit in Percentage," Ira Hobson Young, University of Iowa, 1932.
54. "A Study of the Problems in Teaching the Slide Rule," Carl N. Shuster, Teachers College, Columbia University, 1938.
55. "The Evaluation of a Technique of Study for First Year Algebra," Lawrence G. Bailey, University of Wisconsin, 1931.
56. "Study Helps in Solution of Exercises in Geometry," Harold W. Marshall, University of Wisconsin, 1937.
57. "The Construction and Teaching of a Combined Course in Plane and Solid Geometry for the Tenth Year: An Experimental Study," Jean Fleming Brown, New York University, 1934.
58. "A Technique of Study for the Use of the Formula," Dale M. Schuppener, University of Wisconsin, 1935.

Materials and Instructional Aids

59. "Changes in Materials and Methods in Elementary Algebra from 1829 to 1929," Ira Irl Nelson, University of Texas, 1932.
60. "The Integration of Materials of Instruction and Testing of Outcomes in Business Arithmetic," Wesley Atwood Sowle, University of Pittsburgh, 1940.
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62. "An Experimental Study of the Relative Effectiveness of Certain Visual Aids in Teaching Geometry," Donovan A. Johnson, University of Minnesota, 1949.
63. "Visual Materials for Teaching the Calculus," Allan A. Gibb, Stanford University, 1951.
64. "Percentage Study—an Investigation of Two Kinds of Teaching Material," M. E. Wilker, University of Wisconsin, 1927.
65. "The Production and Experimental Evaluation by the Teacher of a Series of 16 mm. Silent Films for Teaching Mathematics in Grade 7A as Outlined in the Syllabus for the New York City Junior High Schools," Dominick Montelbana, New York University, 1942.

Problem Solving and Understanding Concepts

66. "Real and Genuine Problems in Algebra," Jesse Jerome Powell, Teachers College, Columbia University, 1929.
67. "The Relative Contribution of Certain Factors to Individual Differences in Algebraic Problem Solving Ability," Wylma R. Kellar, Catholic University of America, 1940.
68. "The Problem in High School Algebra," William Albert Landis, Yale University, 1935.
69. "The Role of Insight in Plane Geometry," Lyle K. Henry, University of Iowa, 1933.
70. "Relationship Between Problem-Solving Ability, Computational Skill, Intelligence, and Amount of Training in Mathematics," Philip Brown Norman, Columbia University, 1950.
71. "Improving Linguistic Ability as a Factor in Solving Problems in Algebra," Samuel Reid Hemphill, University of Kansas, 1941.
72. "The Relation of Achievement in Mathematics to Certain Abilities in Problem-Solving," Theodore A. Love, New York University, 1951.
73. "Control of Fundamental Mathematical Skills and Concepts by High School Students," Merle W. Ohlsen, University of Iowa, 1946.

74. "Mastery of Certain Mathematical Concepts by Pupils at the Junior High School Level," Charles H. Butler, University of Missouri, 1931.
75. "Pupil Growth over a Period of Several Months in the Mastery of Certain Mathematical Concepts at the Junior High School Level: an Exploratory Investigation," Amanda Loughren, New York University, 1936.
76. "The Function Concept in Secondary School Mathematics," Herbert R. Hamley, Teachers College, Columbia University, 1932.
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78. "An Experiment in Developing Critical Thinking Through the Teaching of Plane Demonstrative Geometry," Harry Lewis, New York University, 1950.
79. "An Experiment in Teaching Solid Geometry to Provide Training in Thinking," Kenneth B. Henderson, Ohio State University, 1946.
80. "Can the Teaching of Geometry Aid in Cultivating Reflective Thinking?" Gilbert Ulmer, University of Kansas, 1939.
81. "Demonstrative Geometry as a Means for Improving Critical Thinking," Richard Edward Gadske, New York University, 1940.
82. "The Ability of Pupils to Interpret Certain Basic Ideas in Linear Equations," Sherman G. Waggoner, University of Iowa, 1932.
83. "Solving Geometric Originals," F. C. Touton, Teachers College, Columbia University, 1919.
84. "A Study of the Number Concept of Secondary School Mathematics," Howard F. Fehr, Teachers College, Columbia University, 1940.

Achievement

85. "A Study of the Growth and Mastery of Certain Basic Mathematical Understandings on Seven Education Levels," Vincent Joseph Glennon, Harvard University, 1948.
86. "The Effect of Mathematics Courses Pursued in High School Upon Adequate Mastery of or Competence in the Fundamental Mathematical Processes," John C. Heshauer, Pennsylvania State University, 1948.
87. "The Association of Mathematical Achievement with Certain Factors Resident in the Teacher, in the Teaching, in the Pupil, and in the School," Jim R. Schunert, University of Minnesota, 1951.
88. "Competencies Possessed by Secondary School Students and College Students in Arithmetical Fundamentals and Verbal Problems," Werner E. Brand, Colorado State College of Education, 1952.
89. "The Level of Mathematical Competency and Relative Gains in Competency of Pupils Enrolled in Algebra and General Mathematics," Milton William Beckman, University of Nebraska, 1951.
90. "A Study of the Mastery of Mathematical Concepts by Eighth Grade Pupils," Sr. Marie T. Gallagher, Fordham University, 1948.
91. "Nonintellectual Factors in the Learning of General Mathematics," Isaiah Rochlin, University of Chicago, 1952.
92. "The Relationship of Certain Factors to Success in Ninth Grade Algebra," Joseph Alvis Moore, University of Pittsburgh, 1944.
93. "The Effect of Instruction in the Vocabulary of Algebra Upon Achievement in 9th Grade Mathematics," Richard M. Drake, University of Minnesta, 1938.
94. "The Relationship of Certain Reading Abilities to Success in Mathematics at the Ninth Grade Level," Edwin Eagle, Stanford University, 1947.
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96. "The Reading of Verbal Material in Ninth Grade Algebra," Margaret G. McKim, Columbia University, 1942.
97. "Retention of Elementary Algebra Through Quadratics After Varying In-

tervals of Time," Annabel Lee White, Johns Hopkins University, 1930.
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99. "An Investigation of Certain Abilities Fundamental to the Study of Geometry," J. H. Minnick, University of Pennsylvania, 1918.
100. "A Study of Prognosis of Probable Success in Algebra and Geometry," Joseph B. Orleans, Teachers College, Columbia University, 1931.
101. "Characteristic Differences in Mathematical Traits of Good, Average, and Poor Achievers in Demonstrative Geometry," Harry L. Stein, University of Minnesota, 1943.
102. "An Analytical Study of Individual Differences in Plane Geometry," Henry G. Ayre, George Peabody College for Teachers, 1939.
103. "An Investigation of Prognosis in Algebra," Ellis Johnson, Fordham University, 1934.
104. "Effect of the Study of Solid Geometry on Certain Aspects of Space Perception Abilities," Ernest R. Ranucci, Teachers College, Columbia University, 1952.
105. "Training in High School Mathematics Essential for Success in Certain College Subjects," Allan Ray Congdon, Teachers College, Columbia University, 1930.
106. "Mathematics Ability as an Index of Success in Science," Thomas O'Neil, Fordham University, 1931.
107. "Mathematics in the Social Studies," Eugene W. Hellmich, Teachers College, Columbia University, 1935.
108. "The Mathematics Needed in High-School Physics," Louis R. Kilzer, State University of Iowa, 1928.
109. "A Study of Certain Mathematical Abilities in High-School Physics," William Ray Carter, University of Missouri, 1931.
110. "A Critical Study of Errors in Plane Geometry," Herbert D. Welte, State University of Iowa, 1929.
111. "Nature, Frequency and Persistence of Errors Made by Students of First Year Algebra in the Four Fundamental Processes of Addition, Subtraction, Multiplication, and Division," Guy E. Buckingham, Northwestern University, 1930.
112. "Difficulty in First Year Algebra: a Contribution to the Understanding of Error," Paul Gordon Silas, University of Iowa, 1932.
113. "Individual Differences in Learning to Reproduce Plane Figures," Lee Joseph Cronbach, University of Chicago, 1940.
114. "Three Major Difficulties in the Learning of the Demonstrative Geometry," Rolland R. Smith, Teachers College, Columbia University, 1940.

Enrichment-Remediation

115. "Instruments for the Enrichment of Secondary School Mathematics," Randolph Scott Gardner, Columbia University, 1947.
116. "The Effect of a Diagnostic and Remedial Drill System in Arithmetic Computation at the Junior High School Level on Computational Ability, Accuracy, and Self-Reliance in Arithmetic Situations," Harold T. Griffith, Pennsylvania State University, 1949.
117. "The Administration of a Program of Diagnosis and Remedial Instruction in Arithmetic, Reading, and Language Usage in the Secondary School," Ronald B. Thompson, University of Nebraska, 1940.
118. "Special Disability in Algebra," P. M. Symonds, Teachers College, Columbia University, 1923.
119. "The Relative Difficulty of Certain Topics in Mathematics for Slow-Moving Ninth Grade Pupils," Virgil Sampson Mallory, Teachers College, Columbia University, 1938.

Evaluation

120. "Vitalizing Verbal Problem Material; a Manual for Use in Analyzing, Selecting, Teaching, and Appraising Verbal Problem Materials in Ninth Grade Algebra," Melvin O. Alston, Columbia University, 1944.
121. "Evaluation of Achievement and Comparisons of Achievement in First Year Algebra of Public High School Students Grouped According to Their Mathematical Backgrounds and Interests," Robert S. Lankton, University of Michigan, 1951.
122. "First Year Algebra Scales," H. G. Hotz, Teachers College, Columbia University, 1918.
123. "A Study of the Evaluation of Learning in High School Algebra," Virginia M. Porter Sears, Columbia University, 1950.
124. "A Factor-Analysis Study of Prognostic Tests in Algebra," Henry A. Poppen, George Peabody College for Teachers, 1950.
125. "A Factorial Study of Algebraic Abilities," Samuel Bliss Red, University of Texas, 1942.
126. "An Analysis of Algebraic Abilities," J. P. McCoy, University of Iowa, 1924.
127. "A Comparative Study of Achievement Levels of Twelfth Grade Pupils on a Test Designed to Measure Functional Competence in Mathematics," David J. Davis, University of Michigan, 1950.
128. "Constructing and Evaluating Practice Exercises in Mathematics for Students of Vocational Agriculture in Arizona," Russell Walter Cline, Ohio State University, 1940.

ELEMENTARY

History and Textbooks

1. "The Arithmetic Curriculum Since 1860," Harry Louis Metter, University of Illinois, 1933.
2. "Historical Development of Methods in Arithmetic in American Elementary Schools," Lavada Ratliff, University of Texas, 1946.
3. "A Study of Textbook Material in the Field of Arithmetic," Jean F. Hamilton, University of Iowa, 1950.
4. "The Development of Number Meanings in Successive Editions of Recent Third-Grade Arithmetic Texts," Holmes Boynton, Columbia University, 1948.
5. "A Study of the Instructional Material of Textbooks of Arithmetic," Frank Lowrance Wells, State University of Iowa, 1928.
6. "The Use and Value of Supplementary Text Material in Arithmetic," Harvey August Riebe, University of Wisconsin, 1928–29.
7. "Medieval Number Symbolism: Its Sources, Meaning, and Influence on Thought and Expression," Vincent Foster Hopper, Teachers College, Columbia University, 1938.

Teacher Competencies

8. "The Relationship of Estimated Teaching Ability to Pupil Achievement in Reading and Arithmetic," Howard Rice Taylor, Stanford University, 1928.

Curriculum Development

9. "Specific Objectives and Pupil Activities in Arithmetic," W. S. Guiler, University of Chicago, 1923.
10. "Some Facts Concerning Changes in Content and Methods of Arithmetic," Frank H. Gorman, University of Missouri, 1931.
11. "A Particular Program of Instruction in Arithmetic in Grades I, II, III," Daniel Banks Wilburn, George Washington University, 1945.
12. "The Contributions of an Experience Curriculum to Mathematical Learning in the Sixth Grade," Catherine M. Williams, Ohio State University, 1948.

13. "A Program of Motivation and Self-Measurement in the Teaching of Sixth Grade Arithmetic," Omen Bishop, University of Iowa, 1924.
14. "Some Facts Concerning the Functioning of the Missouri State Course of Study in Arithmetic," James Henry Dougherty, Missouri State University, 1933.
15. "A Study of the Use of Arithmetic in the Elementary Schools of Santa Clara County, California," Roy De Verl Willey, Stanford University, 1940.
16. "The Mathematics in Certain Elementary Social Studies in Secondary Schools and Colleges," Eugene W. Hellmich, Teachers College, Columbia University, 1935.
17. "A Study of Children's Mathematical-Interest Questions as a Clue to Grade Placement of Arithmetic Topics," John Austin Morton, Stanford University, 1946.
18. "A Study of Children's Interests in Arithmetic as Indicated by Their Spontaneous Quantitative Expressions in Life Situations," Mary Marjorie Culver, Stanford University, 1942.
19. "Concept of Arithmetic Readiness: Investigation on Second Grade Level," Harold E. Moser, Duke University, 1947.
20. "Adapting the Arithmetic Program to Varying Levels of Ability and Achievement of Pupils Within the Classroom Group," Dwight Hamilton, University of Denver, 1947.
21. "Psychological Analysis of Learning in Arithmetic," C. L. Huffaker, University of Iowa, 1923.
22. "An Experimental Study of the Development of Number Ideas in the Primary Grades," W. A. Brownell, University of Chicago, 1926.
23. "Problems of the City School Superintendent in the Field of Arithmetic," Clarence A. Rubado, Teachers College, Columbia University, 1929.

Teaching Methods

24. "A Study of the Effectiveness of Certain Procedures and Techniques Used in the Teaching of Arithmetic," William Monroe Carter, Colorado State College, 1952.
25. "The Integrated Method Versus the Formal Method in Teaching Arithmetic," James Vintson Cooke, George Peabody College for Teachers, 1938.
26. "A Study of the Effects of Mixed Versus Isolated Drill on the Maintenance of Skills in Arithmetic," Austin C. Repp, State University of Iowa, 1928.
27. "A Comparison of Methods of Teaching Verbal Problems in Arithmetic in Grades 5, 6, 7, and 8," Ralph D. Horsman, University of Pittsburgh, 1940.
28. "The Effect of Using Graded Verbal Problems in Arithmetic for One Year in Grades 4 and 5," Ross M. Gill, University of Pittsburgh, 1940.
29. "The Effect of Practice on the Perception and Memorization of Digits Presented in Single Exposures," Alberta Ethel Banner, Ohio State University, 1936.
30. "The Relative Effectiveness of Drill Periods of Different Length and Frequency in Arithmetic," Bernhard P. Heubner, University of Wisconsin, 1928–29.
31. "A Study of the Learning and Retention of Arithmetic Material Taught to Pupils in Two Ways," William F. Pdolich, Jr., University of Iowa, 1950.
32. "A Comparison of Two Methods of Teaching Arithmetic, Grades I, II, and III," Ethel Lodge Nicholson, University of Pennsylvania, 1943.
33. "Teaching and Testing the Understanding of Common Fractions," Donald C. Steele, University of Pittsburgh, 1940.
34. "Three Methods of Developing Children's Concept of Fractions in Grades V and VI of the Elementary School," Charles F. Howard, University of California, Berkeley, 1948.
35. "A Study of an Individual Instruction Unit in Long Division," Ross Horace Beall, University of Iowa, 1932.
36. "An Experimental Study of Two Methods of Long Division," Kenneth Gary Fuller, Columbia University, 1948.

37. "Skill in Subtraction: The Effect of Changing from the Method of Decomposition to the Method of Equal Additions," James F. Weaver, Johns Hopkins University, 1952.
38. "Experimental Determination of the Degree of Transfer Between Taught and Untaught Combinations in Simple Addition and Subtraction," Herbert Theodore Olander, University of Chicago, 1930.
39. "The Relative Merits of Three Methods of Subtraction: an Experimental Comparison of the Decomposition Method of Subtraction with the Equal Additions Method and the Austrian Method," John Theodore Johnson, Teachers College, Columbia University, 1938.
40. "The Effect of Process Sequence on the Interpretation of Two-Step Problems in Arithmetic," Gunborg Berglund-Gray, University of Pittsburgh, 1938.
41. "The Effect of Process Sequence on the Interpretation of Three Step Problems in Arithmetic," John S. McIsaac, University of Pittsburgh, 1940.
42. "The Teaching of Approximate Computation," Aaron Bakst, Teachers College, Columbia University, 1935.

Materials and Instructional Aids

43. "Workbooks in Arithmetic," Earl Phillip Andreen, Yale University, 1936.
44. "An Experimental Evaluation of Two Kinds of Instructional Material in Sixth Grade Arithmetic," Ira W. Stam, University of Wisconsin, 1933.
45. "A Study of the Relative Effectiveness of Different Types of Graphical Representation at the Elementary School Level," Walter Robert Goetsch, State University of Iowa, 1936.
46. "An Experimental Evaluation of the Relative Effectiveness of the Use of Certain Multisensory Aids in Instruction in Division of Fractions," Robert D. Price, University of Minnesota, 1951.

Problem Solving and Understanding Concepts

47. "A Theoretical and Experimental Analysis of the Problem Solving Process," Elsa E. Robinson, New York University, 1937.
48. "An Evaluation of Arithmetical Problem-Solving Techniques," Ethel M. Sheerin, New York University, 1937.
49. "An Evaluation of Analytic Testing in Arithmetic Problem Solving," Robert L. Burch, Duke University, 1949.
50. "An Experimental Study of Two Types of Arithmetic Problems," Edwin W. Bramhall, New York University, 1939.
51. "A Study of the Comparative Value of Two Methods of Improving Problem Solving Ability in Arithmetic," Roy Edgar Adams, University of Pennsylvania, 1930.
52. "The Relative Effectiveness of Three Methods of Problem Solving," Paul R. Hanna, Teachers College, Columbia University, 1929.
53. "The Relative Merits of Arithmetic Problems of the Conventional Type and Arithmetic Problems of the Imaginative Type," Harry Grove Wheat, Teachers College, Columbia University, 1929.
54. "Awareness in the Inductive Solution of Problems Using Words as Stimuli," Colin James Herrick, University of Pennsylvania, 1939.
55. "The Psychology of Problem Solving in Arithmetic," C. S. Lutes, University of Iowa, 1926.
56. "Factors Associated with Superior and Inferior Achievement in Problem Solving in Sixth Grade Arithmetic: a Statistical Analysis," Carl Wallace Hansen, University of Minnesota, 1943.
57. "Elements of Difficulty in the Interpretation of Concrete Problems in Arithmetic," L. L. Hydle, University of Wisconsin, 1925.
58. "Factors Affecting the Ability to Solve Arithmetic Problems," R. L. Morton, Ohio State University, 1925.
59. "A Diagnosis of Difficulties Encountered in Solving Problems in Arithmetic," M. E. Lazerte, University of Chicago, 1927.

60. "One-Step Problem Patterns and Their Relation to Problem Solving in Arithmetic," Mary E. Sutherland, Columbia University, 1943.
61. "The Effect of Certain Factors in the Verbal Arithmetic Problem Upon Children's Success in the Solution," Grace A. Kramer, Johns Hopkins University, 1933.
62. "The Relationship of Reading Skills to the Ability to Solve Arithmetic Problems," John Patrick Treacy, University of Minnesota, 1943.
63. "The Influence of Specific Drill Exercises in Reading of Various Factors Involved in the Solution of Verbal Problems in Arithmetic," W. O. Shriner, University of Michigan, 1926.
64. "The Relation of Mental Age to Problem Solving Ability in Arithmetic," Sister Mary Frances, University of Cincinnati, 1928.
65. "The Relation of Problem Solving Ability in Arithmetic to Comprehension in Reading," Lorena Stretch, George Peabody College for Teachers, 1931.
66. "Causes of Error in the Interpretation of Concrete Problems in Arithmetic," Robert Timothy McGrath, University of Wisconsin, 1928–29.
67. "Successful and Unsuccessful Problem Solving in Relation to Certain Somatic Activities," Myron S. Clites, Indiana University, 1934.
68. "The Effect of Instruction in Mathematical Vocabulary Upon Problem Solving in Arithmetic," Harry Carl Johnson, University of Minnesota, 1943.
69. "Some Aspects of Arithmetic Problem Solving in the Upper Grades of Rural Schools in the Franklin County, Vermont Northwest School District," Raymond Anderson, New York University, 1943.
70. "Factor of Insight in Arithmetical Efficiency," Samuel M. Levenson, New York University, 1931.
71. "Growth in the Uses of Arithmetic Concepts and Processes," Joy Mahachek, University of Pittsburgh, 1949.
72. "The Emerging Concept of Mental Arithmetic," Caldwell Elwood Boulware, Columbia University, 1950.
73. "Learning the Basic Concepts in Fractions and Their Application in the Addition and Subtraction of Simple Fractions," Sr. M. Theodine Sebold, Catholic University, 1947.

Achievement

74. "The Effect of Awareness of Success on Skill in Arithmetic," Isodoro Pan lasigui, State University of Iowa, 1928.
75. "A Study of the Errors Made in Arithmetic by Fourth, Fifth, and Sixth Grade Pupils in the Public Schools of Davenport, Iowa," William Monroe Carter, Colorado State College, 1951.
76. "The Effect of Certain Immature Procedures on the Learning of Arithmetical Processes by Second-Grade Children," Edwina Deans, University of Cincinnati, 1950.
77. "An Exploratory Investigation of the Effects of Certain Selected Factors Upon Performance of Sixth-Grade Children in Arithmetic," John B. Bouchard, Syracuse University, 1950.
78. "Predicting Arithmetic Achievement on the Basis of Performance at the Grade I Level of the Elementary School," Helen M. Bishop, University of Pittsburgh, 1948.
79. "An Investigation of the Number Abilities of a Group of Bilingual Mexican-American Children in Grade One," Sara A. Rhue, University of Iowa, 1950.
80. "Readiness for Two-Digit Division in Arithmetic," Lawrence J. Smith, Northwestern University, 1952.
81. "Interpretation of Graphs at the Elementary School Level," Sr. Clara Francis Bamberger, S.C.N., Catholic University, 1942.
82. "An Analysis of the Causes of Pupils' Errors in Common Fractions," A. H. Searle, University of Iowa, 1927.

83. "Case Studies of Pupils' Errors in Common Fractions," A. H. Searle, State University of Iowa, 1928.
84. "Diagnosis of Difficulty in Sixth Grade Arithmetic," Peter L. Spencer, Stanford University, 1929.
85. "A Study of Arithmetic Errors," Peter L. Spencer, Stanford University, 1930.
86. "Permanence of Improvement and The Distribution of Learning in Addition and Subtraction," Sr. M. Immaculata Kramer, Catholic University of America, 1931.
87. "Internal Evidence Concerning the Nature of Learning in Beginning Fractions and Mixed Numbers," Arthur U. Edwards, University of Iowa, 1932.
88. "The Types of Errors and Questionable Habits of Work Involved in the Mechanics of Multiplication," Lofton B. Burge, University of Michigan, 1932.
89. "A Controlled Experiment in the Learning of the 100 Addition and the 100 Subtraction Facts," T. Raymond McConnell, University of Iowa, 1933.
90. "Transfer in the Higher-Decade Addition Combinations," Foster Byron Snowden, University of Pittsburgh, 1933.
91. "A Comparative Experimental Study of the Teaching and the Learning of Multiplication in the Elementary Grades," Samuel C. Miller, New York University, 1939.
92. "The Development of Decimal Abilities," Edwin Clark Reichert, University of Minnesota, 1940.
93. "Motivated Drill Work in Third-Grade Arithmetic and Silent Reading," J. H. Hoover, University of Kansas, 1920.
94. "The Verbal Thought and Overt Behavior of Children During Their Learning of Long Division," Casper O. Dahle, State University of Iowa, 1940.
95. "A Study of the Reactions of Pupils While Working on Multiplication of Fractions," Ira Francis Heald, State University of Iowa, 1937.
96. "The Relation Between Quantity and Quality of Learning and Quantity and Quality of Stimulus in Addition of Fractions," Wiley Glen Brooks, State University of Iowa, 1936.
97. "The Adequacy of the Modern Elementary Mathematics Course as a Basis for Comprehending the Mathematical Content of Typical Newspapers and Magazines," Martha Downs, New York University, 1935.
98. "An Experimental Study of the Eye-Voice Span of Oral Column Addition," Iona Cuyler Hamlett, Indiana University, 1934.
99. "A Study of the Simple Integral Processes of Arithmetic," Herbert Re-Barker, George Peabody College for Teachers, 1926.
100. "A Study of the Time Interval Between Stimulus and Response in Arithmetic Fundamentals," Lillian E. Billington, Stanford University, 1947.
101. "An Investigation of the 'Case II' Relationship in Arithmetic," John F. Montgomery, Duke University, 1950.
102. "How Numerals are Read; an Experimental Study of the Reading of Isolated Numerals and Numerals in Arithmetic Problems," P. W. Terry, University of Chicago, 1920.
103. "The Effects on the Psychogalvanic Response of Changes in Complexity and Time Limit of Addition Tests," Richard Sears, University of Michigan, 1931.
104. "An Analysis of Responses Made in Four Narrow Mental Functions Involved in the Computation of Fractions," Marion Cleveland Hayes, State University of Iowa, 1927.
105. "Certain Factors Influencing Relative Difficulty of Grouped Fundamental Arithmetic Combinations," Robert Cary Moon, George Peabody College for Teachers, 1940.
106. "Equations Predicting Demonstrable Gains in Arithmetic in Terms of N Factors," Elton Wayne Beck, State University of Iowa, 1937.
107. "A Survey of the Social and Business Usage of Arithmetic," G. M. Wilson, Teachers College, Columbia University, 1918.

Enrichment-Remediation

108. "Discovery, Identification, and Remedial Treatment of Difficulties in the Fundamental Operations in Elementary School Arithmetic," A. J. Phillips, Toronto University, 1945.
109. "Educational Diagnosis in Arithmetic and Some Suggested Remedial Measures," Celia J. Hatch, University of Wisconsin, 1935.
110. "Proposed Modification of the New York City Course of Study in Arithmetic for Dull Normal Pupils in Grades 1–6," Samuel S. Jaffe, New York University, 1938.

Evaluation

111. "A Survey of the Development of Evaluation in Arithmetical Learnings," Ann Ceal Peters, Columbia University, 1948.
112. "Some Problems in the Measurement of Arithmetic," Rolland Ray, University of Iowa, 1952.
113. "Measurements in the Fundamentals of Arithmetic," T. G. Foran, Catholic University, 1926.
114. "Studies Basic to the Construction and Validation of a Battery of Diagnostic Tests of Problem-Solving in Arithmetic," George E. Crawford, University of Chicago, 1948.
115. "The Statistical Validation of General Achievement Tests in Arithmetic for Grades IV, V, and VI, Using the Universe as the Criterion," Carl R. Streams, University of Pittsburgh, 1952.
116. "Pittsburgh Arithmetic Scales. Pittsburgh, 1923," J. F. Guy, University of Pittsburgh, 1923.
117. "Pittsburgh Arithmetic Tests," Dorothy E. Pickard, University of Pittsburgh, 1950.
118. "Developing Score Cards for the Selection of Elementary Arithmetic," Lloyd H. King, Colorado State College, 1947.

TEACHER TRAINING

1. "Recent Trends in Mathematical Requirements in the Education of Elementary Teachers," Margaret V. Rhoads, Columbia University, 1950.
2. "An Experimental Course for Developing Teaching Competence in Secondary School Mathematics," Joseph L. Slack, Stanford University, 1949.
3. "Correlation of the Professional and Subject Matter Training in the Preparation of Teachers of High School Mathematics," James Francis Whelan, Ohio State University, 1938.
4. "College General Mathematics for Prospective Secondary School Teachers" Lee Emerson Boyer, Pennsylvania State University, 1939.
5. "Criteria for Self-Evaluation of Programs of Student Teaching in Secondary School Mathematics," Toivo E. Rine, George Peabody College for Teachers, 1952.
6. "The Mathematics of General Education for the Teachers," Vesper D. Moore, University of Michigan, 1951.
7. "Exploring the Use of Professional Laboratory Experiences in a Special Methods Course in the Professional Education of Mathematics Teachers," Clarence E. Hardgrove, Ohio State University, 1951.
8. "Arithmetical Knowledges and Skills of Prospective Teachers," J. A. Drushel, New York University, 1927.
9. "Basic College Mathematics for Prospective Elementary School Teachers," Joseph Fuller, University of Pennsylvania, 1945.
10. "A Syllabus of Mathematics 370, the Teaching of Elementary Arithmetic, Grades 4 to 7 Inclusive: a Course in East Texas State Teachers College, Designed to Prepare Teachers of Elementary Arithmetic," Cyrus Wilson LaGrone, New York University, 1937.
11. "Mathematics Teachers' Views Concerning Certain Issues in the Teaching

of Mathematics," Homer Howard, Teachers College, Columbia University, 1940.

12. "The Professional Treatment of the Subject Matter of Arithmetic for Teacher Training Instruction, Grades 1 to 6," Elias A. Bond, Teachers College, Columbia University, 1934.
13. "The Ability of Elementary Teachers in Training and Sixth Grade Children to Solve Certain Arithmetic Problems Mentally, and in any Manner," Jack V. Hall, Colorado State College, 1951.
14. "Elementary Education Majors' Understanding and Knowledge of Common Fractions," Madison Brewer, Colorado State College, 1951.
15. "An Analysis of Errors in Arithmetic Made by Teachers in Training." Velma E. Woods, University of California, Berkeley, 1936.
16. "The Professional Treatment of Freshman Mathematics in Teachers Colleges," Caroline Eucebia Shuler, George Peabody College for Teachers, 1933.
17. "A Survey of State, College, and Municipal Requirements for High School Teachers of Mathematics (Grades Nine to Twelve)," Clarence Milford Bjork, Columbia University, 1950.
18. "Geometry Professionalized for Teachers," Harold W. Christofferson, Teachers College, Columbia University, 1933.
19. "Programs for the Mathematical Education of Prospective Elementary School Teachers in Southern States," Ralph W. Young, University of Florida, 1951.
20. "A Comparative Study of Commercial English, Mathematics, and Science Teachers in the State of New Jersey," P. S. Lomax, New York University, 1927.
21. "A Proposed Program for the Training of Mathematics Teachers for the Public Secondary Schools of Mississippi," Orval Lewis Phillips, Columbia University, 1950.

The table that follows summarizes the number of studies in the various categories of research.

TABULATION OF DOCTORAL DISSERTATIONS BY TOPIC

	Elementary	Secondary		Total
History and Textbooks	7	12		19
Teacher Competencies	1	2		3
Curriculum Development	15	30		45
Teaching Methods	19	14		33
Materials and Instructional Aids	4	7		11
Problem Solving and Understanding Concepts	26	19		45
Achievement	35	30		65
Enrichment-Remediation	3	5		8
Evaluation	8	9		17
Teacher Training			21	21
	118	128	21	267

Challenging the Impossible: a Proposed Trisection of the Angle Using Straightedge and Compass

Comment by Cecil B. Read, Mathematics Editor
University of Wichita, Wichita, Kansas

The accompanying article is one of a series entitled "Challenging the Impossible." The editors of SCHOOL SCIENCE AND MATHEMATICS wish to make it very clear that publication of the article does not indicate approval of the material submitted. However, because of some criticism that mathematicians ignore new solutions or solutions of problems which it is felt have been proved impossible, SCHOOL SCIENCE AND MATHEMATICS will, from time to time, present such solutions or problems.

The mathematics editor found in some places the steps were not sufficiently clear that it was easy to follow what was being done. For example: step 7, "Make an arc of the right angle L," does not specify the radius; step 8 is an awkward statement, as is step 10; step 12 could be worded otherwise, although the intent is clear.

It is suggested that teachers and students interested in a problem of this nature will find it an intriguing task to try to follow the steps in the suggested construction. (This might best be done by attempting to draw a figure, using steps 1–14, without reference to the author's figure.) Of even greater interest will be the attempt to follow the proof and determine whether or not it is valid. If not, where is it not valid?

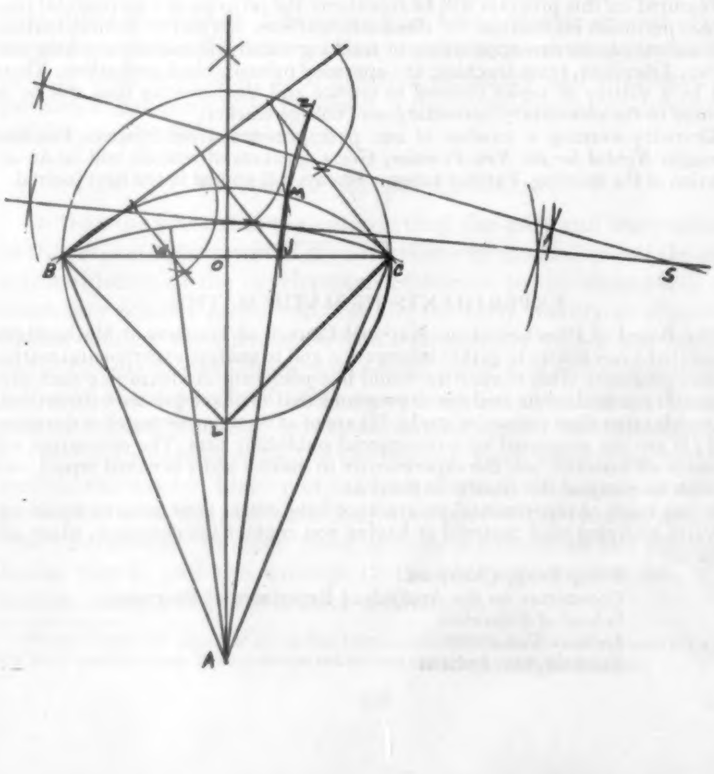
Trisect Angle Using only Compass, Straight Edge and Pencil

Daniel Wade Arthur
P.O. Box 283
Los Angeles, California

1. Given any angle, acute or obtuse, with vertex at A.
2. With any convenient radius, draw an arc of a circle, cutting the sides of the angle at B and C.
3. Draw the straight line BC.
4. Construct the bisector of the angle, intersecting BC at O.
5. With O as center and radius BO or OC, draw a circle intersecting the angle bisector at L, between O and A.
6. Draw a straight line from B to L and from C to L.
7. Make an arc of the right angle L.
8. Trisect the right angle which will be at M.

9. With C as the center and radius of OC or BO, mark off an arc on the semicircle in the angle which falls at Z.
10. Trisect the straight line BC which will be at W and J.
11. Make a straight line from Z to M and from M to J.
12. Bisect the line ZM so that it will make a perpendicular and extend the line on out.
13. Bisect the line MJ so that it will make a perpendicular and make it cross the line that has bisected the line ZM.
14. With S as the center and radius of SZ make an arc through the work that has been done.

I have put within angle A a right angle which is angle L which was obtained by constructing a circle in the angle and so now there is a semicircle within the angle. The arc of any size angle with the width of BC can be put inside the area of the semicircle with the straight line BC the minimum and the semicircle the maximum arc. Within the area of the semicircle there is the arc of the right angle. I trisected each of the arcs the straight line at J, the arc of the right angle at M and the semicircle at Z. Any three points not on a straight line a circle can pass through and so Z, M and J are not in a straight line because



perpendicular bisectors between Z and M and M and J will intersect at S. No matter what the size of the angle is if it has the same width of BC its arc will fall inside the area of the semicircle until the area will apparently become full but it never gets full because the angle can be any length and its arc always gets closer to the straight line if the angle gets longer and it never reaches even though it may seem to. The greater the angle gets its arc will get closer to the semicircle and the smaller the angle gets its arc will get closer to the straight line BC. Since the arc of angle A has to be within the area of the semicircle I have found three points within the area of the semicircle and the arc that passes through these points which are trisected areas will trisect the arc of angle A, therefore, and arc trisects an arc. The arc of angle S with its radius of SZ will trisect the arc of angle A between M and J on the construction.

CASMT CONVENTION

The annual meeting of the Central Association of Science and Mathematics Teachers, *Science and Mathematics for the New Frontier* will be held in Chicago, Illinois, Sheraton Tower Hotel, November 23–25.

Featured on this program will be reports on the progress of experimental programs, pertinent information for classroom teachers, lectures on subject matter, and discussions on new approaches to teaching which will include teaching machines, Television, team teaching, the upgraded primary block and others. There will be a variety of topics covered in science and mathematics that will be of interest to the elementary, secondary, and college teacher.

Thursday evening a number of our past presidents will discuss *Teaching Strengths Needed for the New Frontier*. Guest speakers of renown will be an attraction of the meeting. Further announcements will appear in the next journal.

EXPERIMENTS IN MATHEMATICS

The Board of Directors of the National Council of Teachers of Mathematics appointed a committee to gather information and to analyze experimental mathematics programs. This committee would like your help in identifying such programs. It has limited its analysis to programs that (1) have printed instructional materials other than courses of study, (2) are of at least one semester in duration, and (3) are not sponsored by a commercial publishing firm. The committee will examine all material, ask the experimenter to make a short personal report, and publish as many of the reports as possible.

If you know of experimental programs or have one of your own, we would appreciate receiving your material or having you contact the chairman, whose address is:

Philip Peak, Chairman
Committee on the Analysis of Experimental Programs
School of Education
Indiana University
Bloomington, Indiana

Current Activities in Elementary and Junior High School Science*

Dorothy C. Matala
Iowa State Teachers College, Cedar Falls, Iowa

In the preparation of this working paper an attempt was made to survey the current activities in elementary and junior high school science programs. It was desired to find the new ideas and approaches that may be developing in various areas of the country. Letters were sent to all of the State Departments of Public Instruction requesting such information. At present, responses have been received from half of the states. From these there appears to be much activity, but little of it appears very experimental or innovative. However, when viewed together these activities do indicate some of the trends and the problems of improving the teaching of science at these levels.

The paper will use the following organization in presenting the information available: first, a brief view of the history of science education as background for the current situation; second, rather detailed account of the activities for Iowa because I am most familiar with these and they appear to be rather typical in scope and approach; third, a summary of the activities from other states, especially those that differ from what is happening in Iowa; fourth, special experimental projects and situations that need to be considered for the newness of their approach; and, finally a summary and suggestions of problems that seem to be involved in the improvement of elementary and junior high school sciences.

History of Science Education

In that the present is the outgrowth of the past and the problems of the present are a result of the activities—or inactivity—of the past, a brief history of the development of science in the elementary and secondary schools seems valuable. In the early history of education in this country the curriculum of the elementary school was devoted to the development of literacy—to read, write, and cipher was enough for most of the people. To this was added history. What science, or science-related teaching, was done was incidental and depended on the interest and background of the teacher. Even when done, this was usually the natural history of the immediate environment or was information from the materials that were part of the reading activity. The "academies" devoted most of their curricula to the classics—Latin, Greek, and the writings of the philosophers. Science, if included, was apt to be the science of Aristotle.

* Editor's Note: This paper, and the one that follows, are the third and fourth working papers prepared for the AAAS feasibility study. The introduction and first two papers appeared in the April issue.

During the nineteenth century came many science discoveries and much excitement about science in Europe and this country. As the teachers in the academies came to be more and more college graduates who had had some contact with the science taught in the colleges, science as an organized course came to be part of the curriculum. At first these were natural science courses which dealt with any or all aspects of science. Then these became the special courses of the colleges—botany, zoology, physiology, etc. In the past 50 years we have gradually moved to the more general courses now typical of our secondary schools. The courses as given were simplified editions of the college courses. As larger percentages of the population entered secondary schools it became less and less feasible to try to teach all of them the same materials that were taught in college. So reorganizations of material were made. Botany and zoology became biology. We are still struggling with what such a course should be and do for the secondary school student and we still find that what is being done at the college level is being used to determine what should be in such a course.

While this was happening at the secondary level the science at the elementary level remained "nature study." At its best the teaching of nature study gave the child familiarity with his environment and helped him develop an understanding of the interrelationships of the parts. At its worst it became stylized, formal "object teaching." However, it should be pointed out that in all of this the emphasis was on experience with the materials, on direct contacts and observations to answer the questions raised.

As the numbers of students staying in school to the upper grades increased, it became apparent in the cities that the single teacher in a self-contained classroom could not adequately teach all of the subjects of the class. As a result, about 50 years ago the junior high school was started to allow some specialization for this age group and to offer exploratory work in all of the areas of knowledge that the student would meet in high school. To accomplish this, parts of the science from each area offered in high school were combined to become what is known as general science. The purpose was to familiarize the students with the nature of the specific sciences as well as to offer direct learning experiences. Most of the selection of material that has become traditional in general science was done as the junior high school program developed and has remained in the program to the present. This material was based on the high school program and in general took little or no consideration of any program in the elementary schools.

The critical problem that we now face at the junior high school level

results from an increasingly organized program of science in the elementary schools that has been developing over the last 20–30 years. The Thirty-first Yearbook of the NSSE is one of the major landmarks of the start of this movement. While even today the effectiveness and amount of science taught at the elementary school depends upon the teacher and ranges the full length of any measure that one wants to apply, there is available in all states, to all schools, and to all teachers much material. These consist of courses of study, some very elaborate and detailed, text series, supplementary library books, references for the teacher, suggested activities and teaching techniques. It appears that an interested elementary teacher has at hand a wondrous supply to help do an effective job.

With this development much of the material that was formerly found in the junior high school has been used in the elementary grades. The students seem able to comprehend the ideas, especially if much direct experience is provided. The move in very recent years to include all areas of science at all grades has left the junior high school program caught with apparently nothing new to add. This becomes especially critical when the current texts are the basis of the class work.

Increasingly this problem of overlap and duplication is being recognized. Most of the newer curricula attempt to develop a K-12 program to minimize the repetition. Science and children are changing so rapidly that the guides for accomplishing this are what our teachers need.

Activities in Iowa

The activities going on in Iowa for the improvement of elementary and junior high school science will be described in some detail as this is the state with which I am most familiar. From the responses to the inquiries to the states, I think that what is occurring in Iowa is fairly representative of what is occurring elsewhere with a few very special exceptions which will be described later.

Perhaps the most striking item is the extent to which schools and school systems are concerned about their elementary and junior high programs. In a recent meeting half of the schools represented indicated that revisions were being made or contemplated. This is a good sign but it also makes more critical the problem of possible guidance for the groups that are working with the programs. If teachers spend time and effort in planning and developing a new teaching program, it will be difficult to change this again until there has been time for it to be given a fair test—5 years as a minimum. Hence, it must unfortunately be recognized that for many schools whatever may come out of meetings like these is too late to have a full impact.

The activities in Iowa will be considered under the headings of Curriculum Development, Special Projects, and In-Service Work.

I. *Curriculum Development*

A. State Level

At the state level a K-12 curriculum outline is being developed. For Iowa this is not a revision colored by what has been the past pattern because there has been no science course of study for the elementary grades. The supervision of the production is under the chairmanship of the curriculum director for the State Department of Public Instruction. A Science Area Committee is directly responsible for the planning, the decisions on overall policy, and the integration of the production committees. The production committees are directly responsible for the preparation of the materials for publication. These committees are: primary, intermediate grades, junior high (7–9), biology, chemistry, physics, and advanced science. The members of the committees are teachers of the grade level or subjects involved who are known for their interest, ability, and adequacy of training. In addition each committee may select a consultant to work with it. In general these are college people known for their concern about the training of science teachers or the curriculum in the schools. When first begun there was pressure to complete the material quickly for publication from NDEA funds. However, the decision has been made to take time to do a better job and publish from state funds.

Perhaps the most important decision that has been made—at the recommendation of all of the production committees—is that there will be no attempt to include each area of science at each grade level, rather a "skip" plan is to be used. It is hoped by this to reduce the amount of repetition from grade to grade and the number of areas that are taught in each grade. This will allow more time to be spent with one area; which in turn will allow more time to teach by direct activities and for a wide variety of experiences to help establish the ideas being presented.

The decision concerning a recommended sequence in grades 7–12 has not been finally made. The Area committee has suggested that two patterns be suggested. For the able students this would be:

7th Science, biological emphasis	10th Chemistry
8th Science, physical science	11th Physics
9th Biology	12th Advanced Science

The Junior High Committee does not think this the most effective program. They recommend:

7th and 8th Science, a sequence of 10 units to be taught at the two grades with the sequence to be determined by the local system, depending upon what has been taught in the intermediate grades and the abilities of the teachers. These units are (as presently suggested):

Human physiology
Geology
Meteorology
Astronomy
} (the end of health as part of the science program) terminal units

Energy—forms, sources, etc.
Structure of matter-molecules, atoms, chemical reactions
Measurement-need, degrees of accuracy, units for various phenomena
Plants and animals—some taxonomy, may be an ecological approach.
Electricity and Electronics

9th Physical Science, a combined chemistry and physics course that would include the physical science concepts that are needed as the beginning of the other sciences.

10th, Biology
11th, Physics
12th, Chemistry
} The exact sequence of these might vary with individual students. This does not include an advanced science but the committee feels that if the 9th grade course does what is expected of it, the levels to which the other courses move will be enough greater to compensate for this. The research type study often suggested for advanced science will be supplied by club or interest activities and can extend over several years.

Units are in the process of preparation. It is hoped to publish at least part of the material next summer for trial in the schools.

B. *Local Level*

1. The most extensive science curriculum study with which I am familiar has been going on for 3 years in one medium-sized community. The committee has representation from all levels of the system, K-12, with sub-committees representing the same areas as the state groups. They have approached the problem by first identifying the science ideas that they want to develop and indicating the grade level at which each seems feasible. The concepts for elementary grades were then organized into units. This past summer a workshop was held in which the teachers involved spent part of the time learning the science and part of the time preparing partial unit outlines for use by all of the teachers of grades K-6. These outlines include suggested activities, lists of the films and film-strips that are available, and other teaching aids for each of the concepts included. This year the teachers are using the outlines as far as they have been developed. Each teacher has been asked to keep a record of any additional activities and materials that are

tried and found useful. Next summer these will be incorporated into more complete units. This pattern allows for the contribution of all of the teachers of the grades involved and appears to help develop more interest in really trying the new material. The unit outlines were the basis of equipment and library book purchase for this year.

As side developments from the study, one of the junior college teachers has been given a half-time appointment as elementary science consultant; materials, equipment, and references needed for the units suggested are being supplied to each of the schools; and the purchase of audio-visual materials is being keyed, for the present, to items of value in the new units. A bioscope was placed in each school this fall and the teachers taught how to use it. The elementary supervisor reports that she sees more science activity in the schools this fall than she has seen in years.

2. A second community developed a course of study for the intermediate grades about 5 years ago. They are beginning to revise this. The first suggestion made by the teachers is that the placement of the units will have to be reconsidered. Teachers are finding that units that were of interest when the program was introduced are no longer of great interest at the same grade level. The children appear to know much more science than did children in the same grade even 5 years ago. This appears logical in the light of the increased public interest in science and the increased amount of material that is available to children. This introduces some real problems in making application of tests or even of experimental work in more than one region or of a few years past. Further evidence of this shows up in the use of the 6th grade SRA test on science for grouping of 7th graders. In one community practically all of the class was above the 50th percentile on the national norms and half of them were above the 75th percentile.
3. Probably among the communities in Iowa the greatest concern is for what should be done with the junior high school science program. Almost every superintendent with whom I talk asks what the trends are for these grades. Because of national publicity, talks at superintendents meetings, and the ease with which it can be done, a certain number of schools are moving biology to the 9th grade. At first this is done only for the able students, but with the size of most Iowa schools and the scheduling problems it is being done for all students. This trend has been slow in Iowa. More schools, and many more teachers are favoring the development of a physical science

class for the 9th grade. The factor that is retarding this movement is the lack of a satisfactory text.

In Iowa, and I think in all other states, there is a terrific amount of curriculum revision underway. Its effectiveness will not be known for a number of years. But in all groups with whom I have worked there is a question of doubt as to whether they are doing the right thing. I hear again and again questions on what should be taught at this level. This is partly because there never has been a real analysis of what science understandings the general population should have. The teachers are asking for guidance not in specific grade placement nor in how to teach specific items we already know much better than we do but in what a total program should aim for. In this need such things as an "understanding of the scientific method," "development of a scientific attitude," or "familiarity with the environment" are not enough.

II. *Special Projects in Science*

Under this heading will be included the programs and activities that are primarily for special students, for enrichment, or are feasible in certain communities because of special situations.

A. *Science Seminars*

1. Berg Plan seminars for the science interested and able have developed in a number of Iowa communities with considerable success. These have to the present had very little impact on anything that goes on at the elementary or junior high level. In time they may serve to stimulate more individual activity on the part of some of the students who want to become a part of the seminar when they are advanced enough.
2. The Campus School of the Iowa State Teachers College has for the past 3 summers held an 8-week science-math seminar for junior high school students. Fifty to eighty-five students have been involved each summer with some repeaters. The students are selected on the basis of ability and the recommendation of their teachers as to the degree of the science interest. The program is a very informal one designed for enrichment. Therefore the activities and teaching are centered about aspects of science and math that are not usually a part of the junior high school program in the schools from which the students come. Classes are scheduled from 8:00–12:00 but within a few days the staff finds that if they are to be there ahead of the students it becomes a 7:00–5:00 or longer.

Each student spends part of his time with science and part with mathematics. The science program is based on a series of well-developed guide sheets of activities and experiments for the student to perform. The space and materials are all made available for each student to work in the areas that interest him. Experiences are shared, information pooled, analyses made, and ideas developed.

For the past two summers observer-teachers have been brought in for two-week periods. These teachers have worked with the students but also have held practice and discussion sessions of their own. From this has developed versions of the program modified to fit local facilities and teachers in several other communities in the state.

Support for the student part of the project has been from the college and a nominal fee charged of all participants. Support for the teachers came one year from NSF and last year from the Iowa Association of Manufacturers.

3. This past summer the Fort Dodge school system supported a conservation seminar for 5th and 6th graders. Two teachers who have been to the Iowa Teachers Conservation Camp had charge of the program. Twenty-two children participated for 6 weeks with scarcely any absences. School buses and other facilities were available as needed. The problem that the teachers involved are concerned with at present is what to do with the ones from last summer who want to participate again. While the title was conservation, for the teachers involved this means first a familiarity with the items being conserved. Hence much of the study involved learning about the things and forces that are in our environment. One parent commented upon the tremendous effect the program had on the awareness and observation of the child—every time they went for a ride the child was continually seeing things along the way and pointing them out. Many of the families repeated the trips that the class made! Since awareness and observation are essential attitudes of the scientist this type of experience appears valuable for this age group.

B. *Science Over TV*

1. For 7 years part of Iowa TV-Schooltime from VOI-TV at the Iowa State University has been "Let's Explore Science." This half-hour program once a week is presented by a member of the Science Department of the Iowa State Teachers College. Each lesson has been part of a planned sequence to develop the ideas

that might be expected of 6th graders in an area of science. An outline and suggested follow-up activities is available for each semester. However, this is open-circuit TV and there are no funds available to attempt to work directly with the teachers who may be using the program. We strongly suspect that in a number of cases the viewing of the TV lesson is the only science lesson for the class. We know that in some cases the science lessons were taught page by page from the text and the TV class was watched simply as something extra. However, whenever a study is made of the schools using the programs, science has ranked so high that it cannot be dropped.

2. Last year the Des Moines Public School system started its own Educational-TV station. One of the programs requested by the teachers was science. There is available an outline and suggested follow-up activities. But the teachers have found that they run into trouble because of insufficient references and materials for a really satisfactory follow-up program. In addition the suggestions are not adequate for the uninterested, untrained teacher. Again it appears that more effort should be made to help the teachers in the use of the programs.
3. One school near Des Moines is combining the use of the TV classes with team teaching for the 5th and 6th graders. There are 60–80 students in the classes with 3 teachers. Each teacher takes the responsibility for being the supervising teacher of different subjects. In the follow-up of the TV science class the teachers work with smaller groups for activities and discussion. The only difficulty reported so far is that there is difficulty in getting the students to look and listen to the TV classes as if they were really to learn something and not just for entertainment.

III. *In-Service Work With Teachers*

As most people concerned with science education are aware, one of the major problems at the elementary and junior high level is the training of the teachers—or the lack of it. Hence, the in-service programs that can be developed are of importance not only in what the children may learn but also in the feasibility of some aspects of the curriculum materials.

A. The Iowa State Teachers College has for a long time had a program of consultative service for the schools of the state. At times this means that a college staff member is assigned to the Extension Service for a semester and spends full time wirh the schools that request help. The help takes many forms—the whole range

of the problems of teaching science. In many cases this becomes work with individual teachers to suggest methods or materials by which they could improve their teaching. In many other cases this takes the form of workshops where the teachers are taught some science as well as shown techniques that make for better teaching. At times this program seems a waste of time and funds, but we find it difficult to determine what does really develop from the effort. At the present time science and math are in the greatest demand. In science one full-time and one half-time person are out this semester plus many single trips by other members of the staff.

B. Several colleges of the state conduct extension classes. These may be classes in the teaching of elementary science or they may be classes in one of the sciences themselves. The popularity and effectiveness of these vary with the teacher.

C. In Des Moines the local adult education classes have included a class in elementary science which is proving popular. In addition there is some thinking about trying to devise ways of using their TV station for in-service training.

D. Perhaps the development that we are most pleased to see in the past few years is the hiring of science consultants by the local school systems. Three years ago there were none. We now have three full-time people and two half-time people working in local programs. Where these people have begun work, the elementary science program seems to be gaining stature and continuity seems to be developing.

E. With the sponsorship of the Iowa Science Teachers Association the Junior Colleges of the state held workshops for the elementary teachers of their areas one Saturday in October and will be trying such again later in the year. Where schools are too small to hire science consultants locally and no four-year college is nearby, the development of this relationship as a source of help to the teachers seems to have possibilities.

Activities Within States

(as reported by correspondence)

Not all of the states from whom responses were received will be included in the following descriptions of activities. The selection is made to indicate trends and to emphasize any new thinking or approach that has appeared. Some of the items may seem repetitious, but this is done to indicate areas where uniformity of thinking seems to occur.

I am well aware that there must be many more happenings in the school systems of the states than is here indicated. I can only apolo-

gize for any major omissions and plead the lack of time to contact all of the individuals with whom it was suggested that I correspond. It is probable that participants in the meetings will know of other interesting innovations within the states that they represent. Such contributions should help complete the picture of current activity in the states that is begun here. Copies of most of the material referred to have been sent to me.

State 1

The most recent publication to help teachers with science is *Science Experience for Arkansas Children* published in 1959. This is not intended as a course of study as it does not constitute a complete science program. Rather it is intended as a source booklet to enrich and supplement the science teaching based on selected texts. This is the only course of study which I have examined which is so planned. The suggestion is made that good science experiences for elementary school children can be developed by all good teachers if they are willing to learn with the pupils. Large units which are suggested as possible are: the Universe; the Earth; Conditions Necessary for Life; Living Things; Physical and Chemical Phenomena; Man's Attempt to Control His Environment. In addition sample units, suggestions of seasonal activities, suggestions for such supplementary activities as science exhibits, and fairs, science centers, field trips, tools and supplies, and evaluation are included.

State 2

The current activity in science curricula revolves about the bulletin *The Earmarks of an Effective Program* (Science). This is designed to bring into focus some of the goals or objectives of elementary science. A series of workshops for principals has been held based on this bulletin. A general elementary bulletin is in preparation with a rather general section on science. Curriculum guides will follow, probably by 1962–63 (problem of funds). Ten earmarks are suggested. Among these are:

1. Pupils are given the opportunity to experiment.
2. Time for science is provided at each grade level.
3. Equipment, materials, and space are provided for science instruction.
4. Funds are provided on a regular annual basis for providing equipment and materials.
5. A variety of reading materials for science is available.
6. Use is made of community resources.
7. Science is an integral part of the total educational experience provided by the school.

8. Elementary science deals with all major aspects of the physical and biological environment.
9. The science program is well planned.
10. The science program provides stimulating experiences for pupils of different interests and abilities.

Questions may be raised about some of these. They are included here to indicate the traditional way of thinking about what should be elementary science.

State 3

The most recent publication is *Looking Ahead in Science* which is the report of a production workshop held for 5 days in October 1959. Included is a discussion of teaching science in general terms, suggestions for appropriate experiences for grades K-8 in the form of statements of principles to be taught, suggestions for evaluation, and teaching aids. The 7th and 8th grade programs are linked to the broad social studies areas for these grades.

Three 2-day regional conferences on in-service education in science are being planned for this year. County supervisory personnel will consider the science curriculum problems on Friday and attend one of 8 demonstration workshops on Saturday. It is hoped that these will result in similar workshops for the teachers on the county level.

California required that NDEA funds be spent for special activities and projects—not for the materials, equipment and facilities that the schools should already be providing. These have taken a variety of forms, among them projects to use radio and television as a means of improving and expanding science programs; projects to develop or expand science resource or museum facilities that are designed to serve both school and community needs; science projects which are related to other areas of the curriculum and which involve the develoment of teaching guides or resource units; projects to upgrade teachers qualifications in the field of science (consultants, workshops, demonstration schools).

State 4

There seems to be no recent publication from Kansas, but the following range of activities is reported:

1. A series of elementary science workshops for in-service training to give the teachers experience in working with equipment and materials. Out of this will come a guide on in-service training of elementary science teachers.
2. Twenty-four schools are conducting studies of their elementary programs; 21 elementary and 24 junior highs plan to do so in the 1960–61 school plan.

3. Wichita has initiated a 9th grade course with the emphasis upon laboratory work and a mathematical approach.
4. Lawrence is developing a resource guide for the teaching of elementary science.
5. Sixth grade science in Sabetha is being taught partially through the use of tapes.

State 5

There is a recent publication of science curricula but it is essentially that of New York State. It discusses science teaching suggesting that it should be activity-centered and that the program of a specific system should have the sequence of units planned to suit that system and take advantage of the abilities of the teachers. Major understandings to be taught are listed under 9 major areas. Six work conferences are being planned to discuss the material. Earth science is being suggested for 9th grade. A brief outline listing teaching aids is available.

State 6

Last summer a committee worked on the curriculum for elementary science. Among the recommendations were: more experimental science; a developed program for grades 1–6; and an organized K-12 program. Planning is in progress for a junior high program. It will probably be biological science, earth science and physical science in that order (7, 8, 9).

State 7

A curriculum committee was appointed in 1957 and the material produced was tried in the schools in 1959–60. The junior high curriculum was then revised last summer and the elementary revision will be during the summer of 1961. The committee consisted of teachers with consultants from the colleges. For the junior high the recommendation is biological science, earth science, and physical science in that sequence. However, local units are free to vary the pattern to suit their situations. There is recognition of the paucity of texts to suit this program. The elementary program is built on a plan of including experiences with the same areas and even the same subdivisions of the areas at each level.

State 8

The principal activity reported is the project of the Nebraska Council for Educational Television. Lessons are presented over TV once a week for each grade 4, 5 and 6. A curriculum guide developed by 16 teachers during the past summer is available. Eight schools are participating fully and providing the financing. The most interesting

item is the use of the period at 8:00 A.M. each Thursday as a telecast for teachers—in-service training.

State 9

A draft of science for the elementary schools has been prepared as the result of workshops held in 1956 and 1960. This includes a general discussion of problems, a list of suggestions helpful to elementary teachers (content, activities, references). "Try out" science experiments designed for use in the classrooms are emphasized.

State 10

A science committee has been working and among other things makes the following recommendations:

1. Teachers salaries should be raised.
2. Science courses should include laboratory.
3. No teacher should be assigned to science without adequate college level courses in the science to be taught.
4. General Science should be completed by the 7th grade (Why this break?)
5. The sequence for grades 8–12 should be: general physical science, earth science, general biology, and electives from advanced biology, chemistry, and physics.
6. The sequence through the 10th grade should be required.

State 11

A workshop guide has recently been prepared. This outlines the materials for each grade. The plan is the sequential development of the same topics, the same areas being covered in each grade. The areas are broader than is often the case with a program planned with this approach. Also is included a collection of usable demonstrations. At present a series of 1-day workshops to be followed by an in-service program of 12–16 weeks is being planned. It is hoped by this to stimulate a "back-to-school" movement among the teachers.

State 12

The curriculum publication was prepared in 1957. However, the following trends are indicated as occurring within the state.

1. Downward extension of science programs to each of the elementary grades with specific time allotments in the daily schedule.
2. Curriculum study in science for three purposes: omission of obsolete and irrelevant material; inclusion of the most up-to-date science material; emphasis on science in relation to national survival.
3. Activities—fairs, workshops, camps.

State 13

In 1958, the Oklahoma Curriculum Improvement Commission started a three year study on the improvement of the teaching of science. As a progress report there has recently been published a bulletin on "The Improvement of Science Instruction in Oklahoma, Grades K-12." This consists of some general recommendations as to a science curriculum; a statement on the responsibility of administrators; objectives and developmental concepts for the science to be taught in each of the grades as well as the special secondary sciences; lists of recommended facilities and equipment; and a statement on recommended certification. Among the general recommendations are the following:

1. The science material in the first, second and third grades should probably be integrated with the rest of the daily program, but teachers should be aware of certain basic concepts which should be developed in these years. The program should not be incidental.
2. The program for 4th, 5th, and 6th grades should be designated and have specific periods assigned to it. The science experiences should be of an individual laboratory nature.
3. All school systems should offer a full year of science in both the 7th and 8th grades and all students be required to take these. The 7th grade should place emphasis on the physical and earth sciences and the 8th grade on the biological sciences.
4. A physical science class should be offered in the 9th grade and be required for high school graduation. This course should embody the fundamental concepts of chemistry and physics, especially as regards the structure of the atom and molecules, and the relationships of matter and energy.
5. The specialized high school courses should have as their basic prerequisite the course in physical science and should all be elective and modernized.

This is a somewhat different sequence than is appearing more often in that the 7th grade is physical science and the 8th biological. In looking at the proposed outlines for the courses the 8th grade course will include much of what now comprises high school biology and the biology class will become correspondingly more advanced and modernized. The physics and chemistry courses are also correspondingly at a higher level.

State 14

At present work is being done on a junior high curriculum guide to include activities, texts, references, TV materials, and a list of con-

cepts. Three areas, living things, energy and machines, and the earth and universe are the basis. Science is recommended for each of the grades.

A scope-and-sequence is being developed for K-12. This is being organized in four patterns to fit the variety of teachers—textbook unit, teaching unit, resource unit, and experience unit. These progressively require more initiative and skill with handling many materials on the part of the teacher.

At present the science teachers of the state are being organized into an association that will work through the Oregon Museum of Science and Industry for the improvement of science instruction.

State 15

The greatest amount of activity seems to be centered about the use of films and television in the teaching of science. Science Telecourses have been produced both at Pittsburgh and Philadelphia. These are being made available to other areas through the State Department of Public Instruction. Teachers guides are available and appear to be more adequate than most that I have seen. In addition to use by the classes, TV is being used for in-service training.

Regional film depositories are being established within the state to make films more readily available to the teachers.

A course of study in earth and space science has been developed and a text in process of preparation with the suggestion that it be taught at 9th grade. At present a similarly titled course of study for grades 1–6 is in preparation.

Ground work (committee appointments) is being laid for a three year study of the entire curriculum (all grades, all subjects).

State 16

Curriculum developments have been slow but with the use of NDEA funds work has been done on programs for 8th grade, 9th grade, biology, physics and chemistry.

State 17

The writing of course descriptions for grades 1–12 is in process. In addition a summer writing conference in 1960 prepared a science program for grades 1–9 that is considered terminal. This is the only case of specific planning for such students of which I am aware. In this there is emphasis on the development of a strong science vocabulary; and on basic science rather than technology—on how it works, not on how we use it. A list of principles to be taught at each grade is included with the words to be learned underlined. The principles are listed under physical science, earth science, and biological science, but

it is suggested that related principles be taught in the same unit of study. In this plan the junior high program is biological science, earth science and physical science in that sequence.

For the total K-12 sequence the recommendation for 7–12 segment is "life" sciences, earth sciences, physical sciences, biology, chemistry, physics. This essentially means that in this six year span there are two courses in each of the sciences. The rough and undetailed outlines available indicate repetition.

State 18

Curriculum outlines have been prepared for the elementary grades by bringing the teachers together for a 3–6 week period during the summer. These outlines include concepts and related activities. The same areas are covered in the first three grades, but each of grades 4, 5, and 6 have designated areas with one area of greatest emphasis. Only 3–4 areas are suggested for each of these grades. This appears to be an attempt to reduce the amount of repetition.

State 19

An elementary science curriculum is being tried this year with junior high, biology, chemistry and physics to come. This is the reverse sequence of how curriculum development is usually done.

Nine science curricula workshops were held at 8 state colleges involving 252 public school teachers. The workshops were directed by 20 college professors, half from the academic sciences. In addition 7 county in-service training workshops were held staffed primarily by the persons attending the college workshops. Half a day was spent with the general problems of elementary science teaching. A day and a half were devoted to groups of each grade level working with materials and experiments that are usable at that level. This is the most completely organized in-service program of which I have become aware.

Special Projects and Activities

Under this heading will be described the especially new or experimental projects and studies about which I have been able to collect information. Again, as with the state activities, I am sure that many projects of value and interest will not be included. Sometimes teachers or systems are quietly trying out patterns that are very different but are unaware of the fact—or are hesitant to talk much about it until some results are known. So, again, it will probably happen that the participants at the meetings will add to the items presented here.

New York University Project

The Experimental Teaching Center of the School of Education of

New York University is engaged in helping schools at Long Beach and Ossining, New York and the Pennsbury School at Fallsington, Pennsylvania test what has been called the "dual progress plan" for organizing the intermediate grades. Under this arrangement a student spends part of the day in a classroom with a teacher of a "Core" of subjects that are of his grade level. His promotion through the school depends upon accomplishment with this teacher. The rest of the day he spends with a number of designated subjects—science among them—in a group based on interest and accomplishment in that particular subject. Thus a science class might have children whose grade level ranged from 3–6 but they would all be at about the same level of understanding of the science involved. The class progresses at its best learning rate and might or might not consist of the same members the following year. The science is taught by an elementary teacher who is a science teacher full-time. Each class has about 200 minutes per week of science. (This alone should make for more rapid progress than is accomplished in most schools where a child may have only 60–80 minutes of science per week.)

The program as a whole puts stress on problem-solving thinking, self-directed learning, and creativity. This emphasis plus the rapid and irregular progress of the classes makes the use of the usual science curriculum and grade placement almost impossible. Hence, the Experimental Teaching Center is working with the teachers of the schools involved in the development of a different type of elementary science program. Starting with the premise that all children in their science experience should learn certain basic facts, concepts and principles; certain technological applications of science; the methods of inquiry that are employed by scientists and technologists in acquiring and applying knowledge; and should acquire interest in science, and attitudes and values appropriate to science; the selection of the topics can be keyed to *process* rather than direct information. Three types are suggested: the process of inquiry; the processes in nature (cause-effect relations); and the process of applying knowledge. Using this center for planning, the sequence of topics in elementary science would be based primarily on stages of sophistication in the scientific process of inquiry. For example the first phase of such a program might involve teaching children to classify and arrange objects in various orders and on various bases; to observe and describe similarities and changes; to guess what would happen and to offer explanations. The second phase would teach the terms and procedures required in planning and conducting simple experiments, determining, analyzing, and checking variables. Much more information concerning the development of children and how children think is needed to facilitate the development of an adequate program with this approach.

Astronomy Study, University of Illinois

Dr. J. Myron Atkin, Science Education, and Professor Stanley P. Wyatt, Astronomy, are working with the development of astronomy materials for the intermediate grades that more closely reflect the current interests and concerns of the astronomer. The emphasis is being removed from the learning of the facts of astronomy toward an understanding of it as a field of investigation and how the information has been learned.

Professor Wyatt studied texts and trade books currently available to intermediate grade children and identified several topics that are of importance to the discipline but receive scant attention in the grades —gravitation, radiation, statistical inference, problems of vast distances and ages, problems of origin, and radio astronomy. Teaching material was developed in several areas and presented to different groups by Dr. Atkin.

One group of 4th graders were taught from a historical view of the development of man's conception of the solar system. The children were made responsible for devising a view of the solar system based on knowledge of the ancient and medieval astronomers. They conceptualized a scheme of epicycles to account for the apparent backward movement of the outer planets. Greater appreciation of the Copernican revolution was reached.

Other groups worked with the problem of measuring relatively short distances in space by triangulation or were concerned with basic physical concepts such as mass, inertia, momentum.

The investigators feel that the project has been successful in the general aim of helping children realize some of the problems of astronomers. It is felt that children were helped to see astronomy as a field of problems that challenge the intellect. So far work has been only with the academically talented students. There are some real questions yet as to how generally the material might be used both because of the variation in children and the ability of the teachers.

Illinois Study in Inquiry Training

For three years a study on the improvement of teaching children how to conduct an inquiry has been conducted with fifth graders by some of the staff of the University of Illinois. The procedure has been a formalized one using motion pictures prepared by the experimenting group and verbal "experimentation" on the part of the children. The special activity has been supplemental to the regular science program and conducted for 1 hour a week.

The procedure is to show a short film of a demonstration in physics which poses problems of cause and effect. The children, by the verbal experimentation, are to solve the problems posed by the film. In this the children ask questions by which they gather data and perform

imaginary experiments. These questions must be framed in such a way that the teacher can answer "yes" or "no." The teacher must avoid giving direct information; such as answering a question which is "What would happen if . . . ?" If the question is rephrased to "Would this happen if . . . " the teacher can answer.

The children are given the following three-stage plan of attack on problems to guide them in their questioning:

Stage I Episode analysis—the identification, verification, and measurement of the parameters of the problem;

Stage II Determination of relevance—the identification of the conditions that are necessary and sufficient to produce the events of the episode;

Stage III—the formulation and testing of the theoretical constructs or rules that express the relationships among the variables of the observed physical event.

With practice the children seem to readily formulate questions and progress from stage to stage. This pattern gives the child a plan of operation that will help him to discover causal factors of physical change through his own initiative and control.

Ten students appears to be the optimal group for active participation. In larger classes the rest of the class serve as observers and evaluators in the discussion of the procedure that follows the sessions. The interviews have been taped, reviewed and criticized both by the experimenters and the children and teachers.

Conclusions to the present are:

1. Inquiry skills of 5th graders can be improved over a fifteen week period.
2. More frequent, shorter sessions might be more effective.
3. Children have little desire to improve *per se*. The motivating force is the desire to comprehend causation. If the teacher tells them the cause they are satisfied as with reaching their own conclusion.
4. Inquiry skills cannot be successfully taught in isolation. The major focus of elementary science should remain on content rather than the method of science.

This study seems to verify the idea that children are intellectually curious but it is a curiosity that is satisfied when an answer comes. Like their elders the easiest way to get the answer—ask someone who knows—is the one usually taken.

Teaching General Chemistry to 8th Graders

In Hicksville, New York the teachers became concerned about the amount of repetition in the junior high school program and aware of the amount of science information that many of the children had. A

group of seventh graders with a median IQ of about 120 were selected to participate in the project. As 7th graders they were taught the science background that it was thought they would need to take chemistry as 8th graders. In the 8th grade they took the chemistry course as outlined by the New York State course of study and usually taught to 11th and 12th graders. They took it as an extra subject, met the same number of hours for class and laboratory as did the regular chemistry class.

At the end of the year they took the American Chemical Society Exams and the New York Regents exam in chemistry with the upper classmen. Half of the 8th graders did better than 85% of the students taking the ACS form 1959 on the basis of national norms and half of the class did better than 75% of the students taking the Regents Exam. Thirty-nine of the 44 students qualified for New York State Regents credit in chemistry.

This suggests that 8th graders of ability can perform on a level with the senior high students in the current science courses of the senior high school and probably should be given an opportunity to do so.

This represents the type of activity which I suspect is going on in many places in the country for teachers are aware and concerned and interested in trying new things on their own. These are the type of activity that it is difficult to learn about unless the right person happens to mention it. To me this study points out very strikingly what some teachers have been saying for a period of time; junior high students are ready and able to do much more than we now ask of them, but look at the texts that are available for this level!

Elementary School Seminar

This fall in Washington, D. C. a fifth grade teacher arranged a program of science seminars for selected fifth grade students. The meetings are held after school every two weeks. The seminars are talks by scientists of the area about their work, procedures, problems, and interests. The children have no outside assignments connected with the seminar but are given every opportunity to do further reading or activity. The areas of astronomy, communications, and color are being included in the fall sequence.

Where the scientists are available and willing and the school has the facilities to help the children "follow-up" the talks this should be a rich experience for the interested and able student.

Use of the Lecture Method of Teaching

In two different, widely separated junior highs during the past year I have learned of teachers who are using the lecture technique with

their science students with apparently very good results. One is in an urban area, the other in a consolidated school. Both are aware that they are operating against all of the recommended techniques for this age group and are concerned about being analytical about their results. In both cases the interest and enthusiasm of the students has been pronounced. There are probably other similar situations over the country. These suggest that an evaluation of our methods for use with intermediate and upper grades may be in order. Or is it, in these cases, just the stimulation and excitement of a different technique than the students have met before and a feeling that they are being treated as "adults."

Team-Teaching

One of the newer teaching techniques gaining much publicity and attention and trial in elementary schools is the team-teaching plan developed by the Harvard Graduate School of Education at the Lexington, Massachusetts schools. In this plan a group of teachers handle a group of students—sometimes more than 100 in one group. The team leader is responsible for the over-all planning for the group. The teachers are responsible for the presentation of material to the children. Each member of the teaching corps may have different specialties and abilities which will be used to the best advantage. In addition there are a number of teachers aides, clerks, etc. who are responsible for the many routine non-teaching duties which plague the life of every teacher. Special rooms for special subjects are provided and the children move from room to room, even at the first grade. Some of the teaching is done by lecture techniques to large groups. In a sense the use of TV lessons is the team-teacher approach and lecture technique. These movements seem to indicate that we may expect an increase in "telling" children things by lecture methods. There seems to be no other way yet devised to spread the "master teacher" over large numbers. Studies need to be made of what is gained and lost under these circumstances.

The Elementary School Science Project, University of California

Dr. Robert Karplus, a physicist at the University of California, has become interested in the problems of what should be taught at the elementary grades and how it should be taught. He interested some of his colleagues in the problem and project so that now a team of University scientists are working with elementary teachers to develop and try new activities and approaches for the teaching of science. The approach is, as in a number of the special projects where university scientists are involved, an emphasis on developing an understanding of science as a method and an approach to problems.

Three units have been developed, *Coordinates*, *Forces* and one indicated as biochemical-physiological and called "*What am I*." In the first two, suggested activities and discussion leading to the desired understandings are indicated for three levels—first grade; second, third, fourth grades; and fifth, sixth grades. Each of the later outlines repeats the activities of the lower grade. These have been taught at the levels indicated in an attempt to determine the understanding that can be reached at the various grade levels. The outlines for the teacher are quite detailed and indicate the expected answers and relationships. The program is one of doing or observing and making the meaningful conclusions.

The unit on "Coordinates" may be better as a mathematics unit than as a science unit. It will need to be correlated with the mathematics program of the schools.

The unit on "*What am I?*" appears to me to have much less to offer the student or the teacher. The ideas for really helping to develop the desired understanding through a program of direct experience are quite limited. The teacher is much more often told to "tell" the children information supplied in the unit. There is much less opportunity offered for discovery by the children. It appears to me that a better unit could be pulled together from other material that has been available to elementary teachers and used by many for some time. The lesson on the periodic table is new and imaginative and should provide stimulus and interest. However, it appears to me that this would be more effective in the total program for the elementary school in the context of a study of atoms and molecules in general which should precede the chemical aspects included in this unit. More time has been devoted in the development of this unit to the preparation of word lists, outlines for notebooks, tests to be given, and such routine teaching material. In general, teachers are more competent to do this on their own than to devise the stimulating learning activities.

AAAS Study on the Use of Special Teachers

This is the second year of a AAAS sponsored study on the use of special teachers of science and mathematics for fifth and sixth grades. This is a very controversial plan of organization as far as the specialists in elementary education are concerned. On the other hand, scientists have pretty generally supported the idea as offering a better science program and expressing doubt that there is any great loss to the children in any area of their learning or total school experience.

Four centers are involved in the study—Washington, D. C., Lansing, Michigan, Woodford County, Kentucky (Lexington area), and Cedar Rapids, Iowa. Of these, only Cedar Rapids has had a pattern

of the use of special teachers. In each center two fifth grades and two sixth grades are taught by special teachers of science and mathematics (different teachers but the same classes) and two of each are taught in self-contained classrooms. The children were given achievement tests at the beginning of the year and at the end in science, mathematics, and social studies. In addition, interest inventories, and an IQ measure were used once. Further four children from each class were interviewed with reference to science and four others with reference to mathematics. All eight were asked concerning their reaction to the organization.

The data has not been sufficiently analyzed to allow the making of conclusive statements. However, the first survey of the results of the test in science achievement indicate no significant difference attributable to the organization as such. There seems to be more difference attributable to the variation in teachers, specific classes, and specific groups of children. It appears that the interest and enthusiasm of the teacher has more impact than the organization and that the special teacher is not always the one who has this interest and enthusiasm. There also appears to be some indication that adequate know science information background is not sufficient if the individual does not know elementary children and how to work with them.

In considering the amount of gain from the beginning to the end of the year first made by the classes under each organization, in one center there is no significant difference between the special teachers and the self-contained rooms; in another center the greater gain was made in the self-contained rooms; in another center the greater gain was made in the self-contained rooms; in the other the gain may not be enough greater to be significant. At present we hypothesize teacher difference as being the important factor. However, further analysis may give some other indications.

One rather startling item to appear was the much greater gain made by the fifth graders over that made by the sixth graders with no difference as to organization. Two suggestions are being considered to account for this. One is that the fifth grade program is more effective than the sixth grade one so that the fifth graders have an opportunity to learn more. A second explanation is the one toward which the evaluators lean, that the test does not measure the full learning of the sixth graders. When the scores for the classes in one of the centers was plotted for another study, it was found that some students in each of the classes scored perfect at the beginning of the year and that the median of the group was close to the 75th percentile on norms indicated for the test. This means that our evaluation instrument possibly could not measure the growth of the sixth grade children. But there is no more satisfactory evaluation instrument available.

The children prefer the multiple teacher situation with the greatest degree of preference showing up where the children have the most experience with several teachers. The reasons given by the children are varied and interesting. They range from such as "You probably won't get several teachers all mad at you at the same time," and "You don't have to look at (or listen to) one person all the time;" through ideas related to the suggestion that the experience helps get ready for high school; to the recognition that a teacher who specializes in one area may be able to teach you more in that area. It may be surprising to many adults that the largest number of answers falls in this last category.

Concerning what is liked in science and what ways of learning science are preferred there is a variety of answers. Almost every phase of science is the favorite of some child. One interesting aspect appeared in the interviews this fall. When asked what they would like to study next none of the children answered "chemistry," yet many of them indicated an interest in home activities in chemistry and chemistry sets. This may imply that children develop an association of certain things as being possible in school. Since chemistry had never been studied in school science this was not within the range of topics from which a choice might be made.

The most frequent answer to "What do you like best in science?" was "Experiments." Often this meant demonstrations by the teacher rather than activity by the children, but it meant seeing things actually happen rather than reading about them happening. The next most preferred method of activity was "research reading" to answer questions proposed by themselves or the teacher. This is often done in groups rather than by individuals working alone. It appears to me that there are a number of implications for the material we teach and the way we teach it in the answers of the children. But further study of the results needs to be made before these can be proposed with assurance.

Summary

From the material that has been collected from the states it is obvious that a large amount of interest exists in the improvement of science at the elementary and junior high levels. Much activity is going on in curriculum, trial of new teaching approaches and new aids for the teacher, and in in-service training. It is interesting to note that there is scarcely any work reported on the problems of the preservice training of the teachers. It still seems to be that the colleges are the most difficult to change!

Of the curriculum work being done and the general concern expressed it appears that the most attention is needed and being given to the junior high school level. The curriculum changes being sug-

gested are the most radical for this area. The curriculum patterns for the elementary grades are less changed from earlier issues of the various guides.

There seems to be no question but that among the states responding, general science is on the way out—for ninth grade very quickly and possibly also for seventh and eighth grade. The rapidity of the change may be determined by how quickly adequate texts become available. There is danger in this for in the rush to be first on the market with a book there may be produced very weak ones. If the sample here presented is an indication, the emerging pattern for the seventh, eighth, and ninth grades, the science program is a biological science, earth science, and physical science in that order. This means a specialization of the science area—a separation into different science disciplines—beginning at the seventh grade. Some will ask if this is desirable when we are talking at present of the nned for better understanding of the interrelationships among the sciences.

The use of TV as a supplement to the classroom teacher for science is spreading. In most areas it has the same weaknesses as previously—not enough attention has been paid to the need for helping the teacher make effective use of the TV presentation. Time, money, and effort have gone into the production end, but comparatively little into the receiving end.

The experimental approaches to teaching science, both on what to teach and how to teach it, offer some interesting innovations and possible information. As with many of similar experiments in all phases of teaching, we need to be careful as to how far we generalize as to what can be done in a wide area under many conditions from what can be done in a specific situation. The best example of this is probably the studies at the University of California. What elementary teachers can and will do with the assistance and participation of a team of university scientists is considerably different from what they can and will do when no help is available.

There is indication in a few of the studies that thought concerning how children learn—how children develop concepts—has entered the planning. However, as far as I can tell, little of our information on this has a place in the planning. We know little about children's learning and thinking. What is known should find more application in curriculum work!

PROBLEMS

From the survey of current activities and from my own experiences with curriculum groups, in-service work, and pre-service teaching a number of problems present themselves. For some there are certainly no answers at present. For others—as children's thinking—insufficient of what is known appears to be considered when curriculum

planning is done. At present teachers and curriculum planners must make decisions on most of these questions. Their best judgment is used. But it seems to me that these are some of the problems on which more information and guidance are needed in order to make the judgments sounder.

The problems suggested are grouped under three headings; curriculum, teaching method, and personnel. These areas are, of course, not mutually exclusive but are convenient. The sequence in no way relates to the importance of the problem!

A. Problems Related to Curriculum

1. How do children learn and/or think? How mature do they need to be before they can make comparisons, for example.
2. How *do* children develop abstractions?
3. At what age or grade level will half of a class be able to make abstractions from a wealth of direct experience? From reading?
4. How much direct experience should be provided before children are expected to understand a principle?
5. Is there a "readiness" for science concepts as for other learning and skills? What determines this "readiness?" Is there consistency in its development?
6. What is the most effective pattern for the curriculum—spiral, skip, or some other? Is the same pattern equally effective throughout the elementary and junior high grades?
7. How can science curricula be correlated with mathematics, social science, language arts, etc. to take advantage of the skills and understandings developed in these areas?
8. What should be taught at various grade levels? What are the criteria valuable for this selection?
9. Should all schools follow the same curriculum? For all grade levels?
10. What should be the emphasis of the science program?
11. What principles of science should the general public understand? To what depth?
12. What is the most effective time allotment and arrangement?
13. Can scientific method and attitude be taught specifically or do these result from the way science is taught?
14. What are adequate and valid testing instruments for evaluating all that we try to accomplish in science teaching.

B. Problems Related to Methods

1. How much direct experience is needed to develop science understandings? Is it desirable? Is this the same for all levels?
2. How can a "master-teacher" or TV-teacher-lecturer best be utilized? With what grade levels are these effective?
3. How much should children do experiments or activities that illustrate ideas? How much and when is demonstration enough?
4. How well do children at various ages visualize from reading or being told?
5. What equipment and/or materials should be available at various grades?
6. Of what value are workbooks, notebooks, etc? Under what conditions?
7. What is the importance of a textbook? How can one be used effectively?
8. Should special rooms with special equipment be available for science? At what grade levels?
9. What aids should be available to teachers to enable them to avoid a "read-recite-test" type of science program?
10. How extensive should an elementary library be? One for junior high? How should the books be selected?

C. Problems Related to Personnel

1. Should science be taught by a special teacher? At what grade levels?
2. What are the qualifications needed by a special teacher? Should there be certification for this?
3. What pre-service science should be required of teachers? Does this differ with grade levels?
4. What is the function of a science consultant? The qualifications?
5. With how many grades and teachers can a consultant effectively work?
6. What are the most effective in-service programs?
7. How might TV be used with in-service programs?
8. How can superintendents be made aware of the importance of teachers with competency in the areas that they teach?

If these are not enough, the big problem already mentioned raises its head—how extensively and freely can results from trials in one school be applied to other schools?

A Statement of Bias

No one who works for long or intensively in an area can help but develop opinions and beliefs. No matter how objective one tries to be in evaluating what others do in that particular area, the beliefs—the bias—influences all reactions. Since I have been responsible for selecting the items to be included, it seems fair to indicate some of my beliefs about elementary and junior high science programs and teaching.

First, I believe *strongly* that science should be taught as an activity program in which the children have as much direct experience with the phenomena as is possible using as many senses and as wide a variety of sources as possible. This means that we do not perform a lone demonstration and expect children to draw broad generalizations from it! Further it means a reduction in the number of ideas introduced at any one grade so that there is time to work with an idea in different contexts. Further it means space and equipment for the children to *do* things.

Second, I believe that we should not try to force children into stating abstractions in the lower grades. An abstraction to be more than a mere repetition of words must be built on a wealth of experience. This means that the grades should supply this experience in increasing complexity so that when students can develop abstractions they have some basis on which to do it. This also takes time.

Third, I believe that returning to the same topics in each grade leads to superficial treatment at all levels, repetition between grades, and boredom with the whole subject. This means that I favor the development of a sequence of topics to be taught within a block of grades and repeated in a later block.

Fourth, I believe that children are intellectually curious and want to know about the phenomena in their environment—that one of their "needs" is such information. This means that familiarity with

an understanding of local phenomena should receive attention. Call this "nature study" if you will, but use Jackman's definitions and approach.

Fifth, I believe that many elementary teachers are doing a better job of science teaching than they are given credit for. Further that their efficiency is decreasing because of feelings of insecurity that uninformed criticism is causing to develop. Where they are not doing a passable job it is very often the fault of the teacher-training program and of the *kinds* of courses they were given in college.

Sixth, I do not believe in moving biology to the ninth grade.

Seventh (and related) I do not believe in putting the traditional general science all into seventh and eighth grades. It would still be too superficial. These grades need a new approach.

THE AGE OF ANCIENT GLASS MEASURED BY ITS CRUST

The age of ancient glass can now be measured by counting rings in its weathered crust.

Dr. Robert H. Brill of The Corning Museum of Glass and Harrison P. Hood of Corning Glass Works developed the new dating method.

When objects of glass are buried in soil for a long time or submerged under water, they often undergo a slow chemical deterioration that produces a surface crust. This is comparable to the rusting of metal objects but takes place at a much slower rate.

When the weathering crust, generally one to two millimeters thick, is examined in cross-section under a microscope, tiny separated layers can be observed. These layers are so thin that about 30 of them would have to be stacked to make the thickness of a human hair.

The scientists assume on the basis of good chemical evidence that a single layer is the result of one year's decomposition. By counting the layers, how long the glass has been buried can be determined.

The method is similar to the counting of tree rings to measure a tree's age, except that the glass-age method involves a destructive process rather than a process of growth.

Validity of the method was tested by counting layers in weathering crusts from objects buried for known periods of time.

The oldest object yet studied was a fragment found in the ruins of the ancient city of Sardis, Turkey. The building where it was found is believed to have been built in the late third century and was probably destroyed early in the seventh century. The ring-counting technique indicated the fragment was buried about 378 A.D., plus or minus ten years.

Review of Science Textbooks Currently Used in Elementary Schools

Albert Piltz
Supervisor of Science, Detroit Public Schools

A science textbook is to be differentiated from trade, supplementary or reference books commonly found in elementary classrooms. Although it may be used in a variety of ways, it is more nearly defined as a basic book specific to the instructional program, a copy of which is expected to be available for the individual use of each pupil in the classroom.

There are, in the main, about ten major science text series commonly used in elementary schools. There is a book for each grade level from kindergarten through sixth grade in a textbook series. Some texts may combine kindergarten with first grade. Each book in the text series consists of a variety of subject matter, often organized into units of some breadth and dealing with topics such as the earth, plants and animals, electricity, machines and the like. There are also some "unit-type" textbooks available, usually of pamphlet size, which deal with a specific area of science. Publishers of this type indicate the grade level or levels at which the materials are likely to be used more effectively. Some claim is made by publishers, of this type of text, that they may be more adaptable to a locally developed guide or course of study and easier to adjust to the wide range of reading abilities of children than the conventional type text. However, counter claim by publishers states that there is less likely to be integration among the topics in the "unit-type" textbooks than among the areas found in conventional textbooks.

Use of Textbooks

Although textbooks should be inextricably tied in with curriculum, there is much evidence to indicate that many teachers lack knowledge of the textbook's function in a modern science program. There is as great a variation in the use of textbooks as there are ways that science is taught by the individual teacher.

Except for an occasional reference, some classroom teachers seldom use the textbook. Others may use it merely for ideas which they use with children in discussion and demonstration. A great many teachers rely heavily on the textbook to shape their science program—and it often becomes the mainstay of such a program. The latter may be especially true for teachers who lack confidence in their knowledge of content and who feel insecure in teaching science. If this is the case, science may become almost entirely a reading activity. One pupil will

read a paragraph in a text and another pupil will continue with a second paragraph until the unit is completed. An occasional demonstration may be performed by the teacher, providing it is clearly described in the text and the material is available, but questions arising from the text may be discouraged if the teacher's background is inadequate. It is obvious what the implication may be to the learners. The pupil is challenged to experience only to the degree that the text guides or directs him to activity. This points up the need for guidance in the proper use of texts. Complete reliance on learning science through the sole medium of "reading about science" leaves much to be desired. A skillful teacher attempts to maintain an equilibrium between reading and other learning activities and makes selection on the basis of what is best for the pupil in a given learning situation. Some authors, cognizant of good teaching practice, frequently suggest activities which heighten observation and experiment and which go beyond the confines of the textbook. Reading is an important tool to use in learning science and textbooks may insure a developmental program and serve a unique function in the learning process.

Type of Approaches in the Use of Textbooks

Many elementary schools use the multi-text approach in teaching science. A variety of texts, supplementary, grade, and reference books of different reading levels representing many authors, are available to pupils. These are used as sources of information when the situation warrants it. Often in this approach, provision is made for a curriculum guide or course of study which the teacher uses for direction. The guide may suggest reading material listed by title and page number in addition to helps in content and method to supplement program.

Many elementary schools may also have either a single or dual textbook adoption. A single adoption would relegate the teacher to the use of a single textbook. A dual adoption would provide the teacher with a choice of selection from two text series. In either situation supplementary books could be used in conjunction with the texts. Administrators often encourage teachers to make use of the manual which accompanies the text. It is designed primarily to provide helpful suggestions to the teacher for more efficient use of the texts and information on grade placement of content, text materials and instructional aids. In addition, outlines of the content-to-be covered in the text by grade levels and frequently referred to as "scope and sequence" charts, are provided by publishers. These outlines carefully illustrate a type of continuous program in science from kindergarten through sixth grade. Often the manuals become the course of study (curriculum guide, or syllabus) for the elementary teacher. Conflict may arise when a teacher needs to reconcile a State

or local guide with the manual. Unless careful provision is made to anticipate this problem (if the texts are used to any extent), the teacher will likely use the manual.

Progress in Textbook Development

In recent years there has been great improvement in the quality of the science texts available for elementary grades. An atrractive format, abundant illustrations and handsome color printing are in marked contrast to the less inviting books of a decade or so ago. Most of the texts have abandoned the dialogue technic or "Dick tells Jane" approach as a means of enlivening the material, and authors have made significant progress in writing in a manner that opens the fascination inherent in science to young readers. Many of the books also reveal that the author is familiar with what is known about how children learn. For example, the question-and-answer approach, usually absent in the earlier books, is now common. The author is also better grounded in science content. Although inaccuracies still persist, attempts are made to hold them to a minimum.

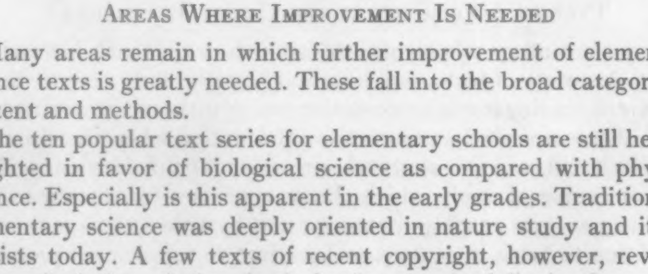
Areas Where Improvement Is Needed

Many areas remain in which further improvement of elementary science texts is greatly needed. These fall into the broad categories of content and methods.

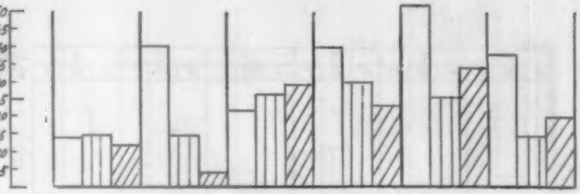
The ten popular text series for elementary schools are still heavily weighted in favor of biological science as compared with physical science. Especially is this apparent in the early grades. Traditionally, elementary science was deeply oriented in nature study and it still persists today. A few texts of recent copyright, however, reveal a greater inclusion of the physical sciences especially in the area of space and atomic science in the upper elementary grades. The range of topics covered is quite diverse among the various series and an imbalance is often found within a single text (see chart following).

A study showing a comparison of three series of science books as to some content covered at each grade level.

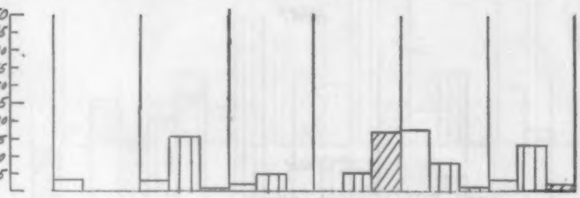
Credit given in tabulation only when content covered a complete page.



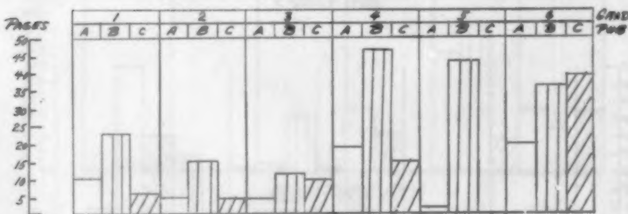
AIR



PLANTS

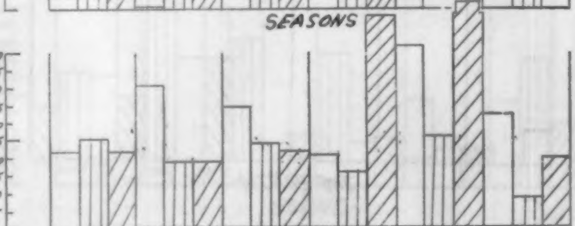


MAGNETISM

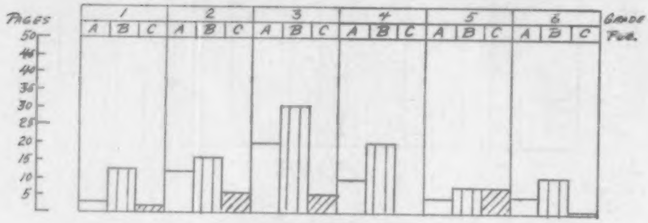


THE UNIVERSE

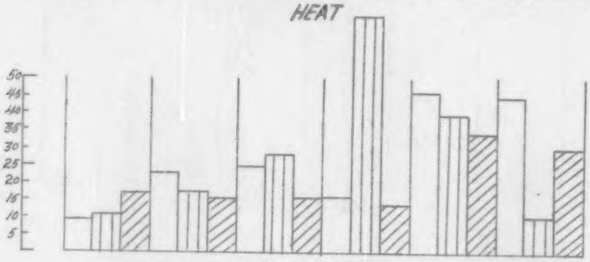
SEASONS



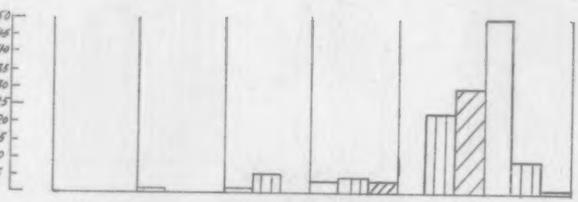
ANIMALS



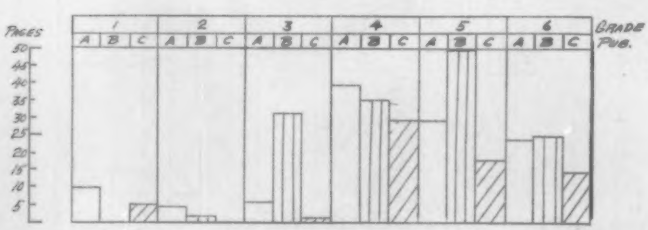
HEAT



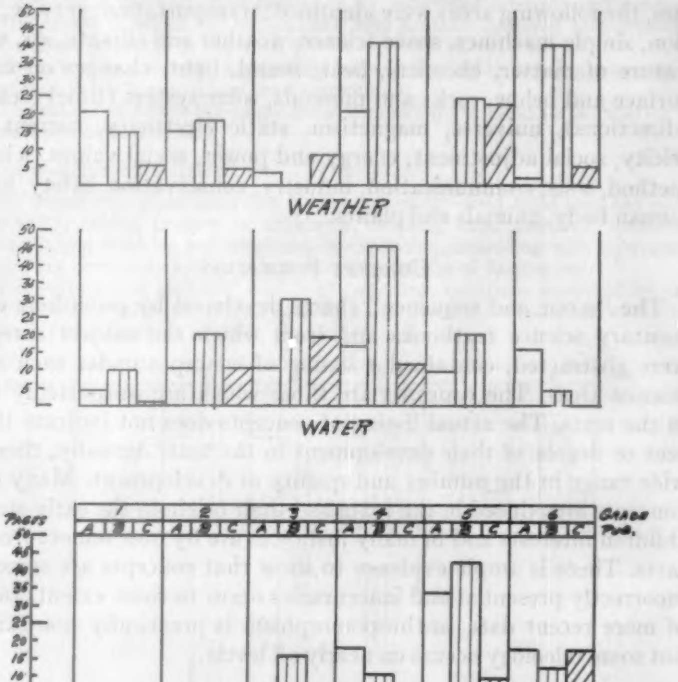
MACHINES



CONSERVATION



THE EARTH


WEATHER
WATER
PAGES
GRADE
PUB.
1 2 3 4 5 6
A B C A B C A B C A B C A B C A B C
ELECTRICITY
LIGHT
SOUND

In a compilation of subject categories from the prevailing text series, the following areas were identified: transportation, gravity, aviation, simple machines, space science, weather and climate, air, water, nature of matter, chemical, heat, sound, light, changes on earth's surface and below, rocks and minerals, solar system (time) (seasons) (directions), universe, magnetism, static electricity, current electricity, social adjustment, energy and power, social values, scientific method, soils, communication, industry, conservation, safety, health, human body, animals and plants.

Concept Formation

The "scope and sequence" charts developed by publishers of elementary science textbooks and from which the subject categories were abstracted, contained a listing of concepts under each of the science areas. The concepts are those which are purportedly found in the texts. The actual listing of concepts does not indicate the extent or degree of their development in the text. Actually, there is a wide range in the number and quality of development. Many of the concepts introduced in the texts had their origin in the early study of children interests and in many instances are by now remote from the facts. There is ample evidence to show that concepts are sometimes incorrectly presented and inaccuracies occur to some extent. In texts of more recent date, anthropomorphism is practically non-existent, but some teleology occurs on nearly all levels.

Scientific Attitudes and Critical Thinking

In a study to determine the provisions made in texts for fostering scientific attitudes and developing critical thinking through content and concept formation, it was found that in a large number of texts examined there was limited opportunity for children to generalize or make application. Many of the generalizations were already made for the child. There were few questions in the content which stimulated children to do critical thinking and in several instances the content was written in such a way as to do little developing of scientific attitudes. Books in grades five and six showed somewhat better treatment in posing questions of how, why and what is compared with grades 1–3. Interestingly enough, when texts were examined to determine the degree to which children are encouraged to go beyond the ideas in the book, it was found that books in the middle grades were slightly favored over the early and later grades (see chart following.)

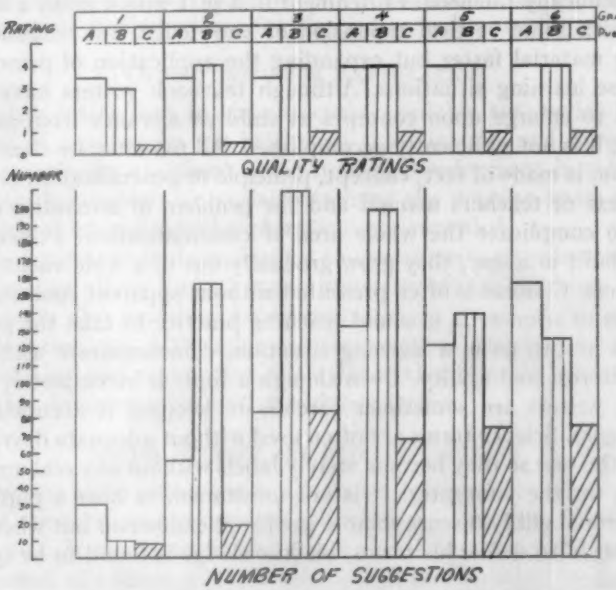
A Study Showing a Comparison of Three Series of Science Books as to Suggestions for Encouraging the Child to Go Beyond the Ideas in the Book.

Quality rating determined by:

1. The variety of suggestions given in end-of-unit activities and at end-of-areas within the unit, thus providing for individual interests and needs.
2. The extent to which the suggestions were problem-centered and extended the main learnings in the unit.
3. The extent to which the suggestions helped the child in learning more about science in his home, school, and community.
4. The extent to which the suggestions stimulated the child to be creative in his ways of finding out.

Number of suggestions arrived at:

1. By tabulating ideas according to the following—field trips into the community, asking persons in authority, reading, experimenting, questions simulating thinking and requiring investigation, collecting with a purpose, making notebooks and booklets recording results of finding out.
2. The exclusion of all "yes" and "no" questions, questions answered by one word or factual in nature, all activities and questions which indicated that the information was given in the unit.



GRADES	A QUALITY	A NUMBER	B QUALITY	B NUMBER	C QUALITY	C NUMBER
1	3.5	31	3	10	0	8
2	3.5	55	4	156	.5	18
3	3.5	83	4	209	1	83
4	4	138	4	199	1	67
5	4	121	4	139	1	75
6	4	158	4	124	1	78

Suggestions to Encourage the Child to Go Beyond the Ideas in the Book.

Some observers have assessed the presently available text series as superficial, emphasizing the application or technology of science to the exclusion of material that is considered fundamental today.

Going beyond the Text

Much of the material in the textbooks now being used is descriptive, dealing with processes. The books are full of how things work and where they are found but they seldom approach the "why" of science. It is hard to find material which will permit a student to go as deeply into a subject as his capacity and potential will permit. Descriptive material is especially dominant in the texts in the early elementary grades. Even though depth studies in early childhood education reveal that young children have greater acumen for science than formerly believed, it is seldom reflected in the writing on this level. Little attention is characteristically given to holding the interest of over-achievers—the very group who are most likely to find a career interest in science. Little provision is made for enrichment of the academically talented. Enrichment in a text would mean a horizontal with some vertical expansion of knowledge, not necessarily covering material faster but expanding the application of principle in diverse learning situations. Although textbook writers have attempted to enlarge upon concepts as children advance from grade to grade, it is not sufficiently accomplished. All too often no clear cut distinction is made of fact, concept, principle or generalization either in the text or teachers manual and the problem of semantics continues to complicate the whole area of communication. Principles are not built in a day, they grow gradually out of a wide variety of experiences. Content is often presented without apparent concern for principles of science. It is sound teaching practice to take the pupil as far as he can go in a learning situation, commensurate with his needs, interest and ability. Even though a topic is incompletely developed, writers are sometimes careless in keeping it accurate as far as it goes. Science terms are often used without adequate development in the text so they become merely labels without any real understanding for the youngster. It is not uncommon to hear a pupil in the classroom glibly discuss some scientific phenomenon but when he is challenged to define his terms, his knowledge is found to be quite superficial.

Children could develop greater understanding in science if texts would give greater focus to situations in which pupils could improve their skill in problem solving. Most current texts are deficient in the development of sufficient numbers of problems significant to children and in devising expriences which are problem centered. Some of the best learning in science has resulted when youngsters have been stimulated by reading to investigate, experiment, observe carefully, gathering data and draw conclusions. Youngsters are perfectly capable of carrying on simple research studies with varying degrees of sophistication depending on their ability and level of maturity. Ques-

tions such as "How do you know?"; "How can this be explained?"; "How can you find out?"; "What principle of science would you apply?" and "Try it and see" challenges the reader to discover for himself the basic meaning of science.

Discovery of Principles

Since new innovations in science are multiplying far beyond the ability of the teacher to keep abreast of them, texts should reflect both basic and applied aspects of science. In each subject, the use of basic principles would permit greater depth as well as horizontal extension in science teaching. Many of the scientific societies that are now engaged in course content revision in secondary school science are using principles as the basis of their course outlines. Authors of elementary texts could introduce units with basic theory and use technology or applied science for illustration and example.

Opportunity for Exploration

Another major lack in the presently available text series is the scarcity of suggestions for individual investigation and discovery. All the textbooks examined are in need of development in this area but there is considerable variation among the popular series in the extent to which individual explorations are provided.

It is common to find conclusions to experiments cited in the text. This practice allows limited opportunity for critical thinking. Little provision is also made for experimentation as a way of finding answers to questions. Although some texts suggest activities involving manipulation and exploration, little distinction is made between experiment, demonstration and experience.

Social Studies and Science Content

A few text series reflect the social studies approach to science teaching but the relationship between science and social studies is not always clear. It would seem that social studies content is forced into the context of science without the natural development more characteristic of straight science writing. Much of the social studies content found in texts is implied through pictures of home and community. Some historical events such as the invention of the telegraph and the airplane are frequently found in many texts. Some books also emphasize community services, disposal of waste, police protection and various aspects of the culture of the American Indians.

Readability Standards

Many publishers apply controlled vocabulary tests and readability formulae to their science texts. If the test is valid and reliable at the

age level for which it is used, it should be a useful index of the readability of the book. Publishers often provide such information to textbook selection committees when texts are being evaluated. Sentence lengths are also controlled, especially in the early grades. Up through grade three, many texts limit sentence length to 14 words, some averaging seven. Number of words per sentence increases gradually until a limit of 24 words is reached at grade six, many averaging not more than 11–15. In general, most readability tests are scaled higher than the comprehension of the average pupil at a given grade. The situation today is not unlike the condition existing ten years ago when Dr. George Mallinson, in his study at that time on the Reading Difficulty of Science Textbooks, found that in general, many of the textbooks in elementary science for grade four are far too difficult for the fourth grader of average reading ability. The fifth-grade textbooks in science are rather difficult for the average fifth-grader, and the sixth-grade books are slightly difficult for the average sixth-grader. At any rate, none of them could be construed as being easy reading material. He also inferred that the reading difficulty might be partially responsible for the inability of these pupils to comprehend easily the concepts and topics of science presented in them.

Textbook Selection

In recent years careful attention has been given to the selection of textbooks for adoption in a school system. It is common practice today for State, county and local boards of education to appoint committees charged with the responsibility for textbook selection. These committees are often composed of teachers, principals, supervisors and administrators who deliberate for a period of time and select a textbook series for a school system. A great many boards of education have a book adoption every five years. To guide them in their efforts in textbook selection, committees will usually develop or obtain a list of criteria which they use in evaluation. A set of these criteria becomes the instrument or standard for rating and comparing texts. The check list below is a typical instrument devised by a large school system used in rating rextbooks.

Conclusion

As significant as textbooks are in the educative process, they have their limitations much like other tools of learning. How much can be expected of textbooks by students and teachers in the science enterprise depends on their ability to utilize them effectively.

Publishers are continuously striving to improve the quality of textbooks but may be handicapped by the dearth of writers who have

competence in both science and education and who also possess creativity and skill in writing for children of elementary school age. As competition for the services of proficient textbook writers increases the availability of them seems to decrease. Often great reliance is placed on the talents of the editor to synthesize materials produced by many writers of diverse background and ability in the production of a text.

It has also been found that some textbooks of recent copyright dates show little change from previous printing. Book selection committees, cognizant of the need for up-to-date texts, often refer to copyrights when evaluating texts and may not make comparisons of the same text of an earlier edition.

There is a need to emphasize again the progress made in textbook writing today as compared to texts of yesteryear. The progress in elementary science teaching would not appear to be as great by comparison. This lag might be overcome, in part, if a concerted effort were made to make available to teachers the means by which they could improve their effectiveness in using texts to their fullest potential.

CRITERIA FOR SELECTION OF ELEMENTARY SCIENCE TEXTBOOKS, GRADES 1–6*

Criteria	Publishers									
	D. C. Heath	Singer	Scribners	Lippincott	Allyn & Bacon	Beckley-Cardy	Winston	Macmillan	Ginn	Lyons and Carnahan
I. Attractiveness and usability for teachers and pupils: 1. format-printing, size of type 2. size of book, open pages, amount of white space 3. binding, cover, durability 4. glossary, table of contents, index, bibliography										
II. Qualification of authors: 1. background and experience, elementary science teaching, elementary supervision 2. publications on method and procedure, evidence of research										
III. Readability: 1. reading level with respect to concept development 2. sentence length and space between lines conducive to easy reading										
IV. Guides and Teaching Aids: 1. teacher manuals suitable to the inexperienced science teacher as well as the experienced science teacher 2. bibliography for teachers										
V. Visual Aids: 1. quality, accuracy and sufficiency of diagrammatic drawings, pictures, charts, graphs and tables 2. up-to-dateness of diagrammatic drawings, pictures, charts, graphs and tables 3. contribution to the understanding of content										

* Developed by Book Selection Committee, Detroit Public Schools, Detroit, Michigan.

Criteria	Publishers: D. C. Heath	Singer	Scribners	Lippincott	Allyn & Bacon	Beckley-Cardy	Winston	Macmillan	Ginn	Lyons and Carnahan
VI. Provision for individual differences:										
1. additional science experiences sufficient to keep the learner working to capacity										
VII. Basic Philosophy:										
1. content promotes scientific attitudes and the use of the scientific method										
2. promotes understanding and application of the way scientists have influenced history with inventions and discoveries										
VIII. Readiness:										
1. book so written that meanings are established before new concepts are introduced										
2. skills are developed in terms of readiness										
IX. Developmental methods:										
1. science concepts related to social applications such as health, safety, conservation, etc.										
2. known method (scientific problem solving) used in the solutions of new problems										
3. book provides opportunity for the child to learn by doing										
4. explanations of scientific principles made in short, simple, understandable language										
5. pupils' thinking guides through thought-provoking questions, suggestions, and directions										
6. pupils led to generalize about new experiences on the level of meaning and understanding										
7. problems and subject matter left open-ended (no problem finite or subject matter all inclusive)										
8. stresses principles and uses technology as application of principles										
X. Content:										
1. progresses and expands through a building-up process which represents a continuous reorganization of past experience—leads to emphasis upon relationships										
2. leads to understanding in other subject matter areas										
3. leads to greater appreciations of human relationships										
4. presents science as a body of organized facts based upon accepted scientific principles which will enable the child to draw generalizations concerning his environment										
5. material up-to-date and related to the daily life of the child each unit sufficiently independent to allow for "incidental teaching"										
XI. Problem solving:										
1. an inherent part of the regular quantity, and variety of science experiences										
2. book provides abundant opportunity for children to explore and discover for themselves										
XII. Balance:										
1. must exist between the physical and biological sciences										

Intuitive Ideas of Perspective

Ali R. Amir-Moez
Purdue University, Lafayette, Indiana

I have discovered the sad fact that many people have finished school without being able to draw a picture of a solid object on a piece of paper. I have even had students who had a great desire to become engineers or scientists and had to give up trying because they couldn't draw. In what follows we shall give some ideas of perspective intuitively.

1. *Simple objects:* We shall begin with different ways in which a square can be seen in perspective. If we are facing the square, it looks perfect (Fig. 1). If we are not facing the square, it might look like a parallelogram (Fig. 2).

Let us put a few squares together and see what we can do with them. For example let us draw a box with square sides.

Step 1: Draw the side that faces us (Fig. 3).

Step 2: Add to it the side that we see in perspective, that is, the side which is not exactly in the front of us (Fig. 4).

Step 3: Add the top (Fig. 5).

Step 4: Shade figure 5 to make it stand out (Fig. 6).

Shading is very important, and depends very much on one's imagination.

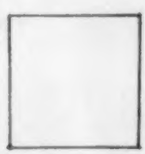


FIG. 1

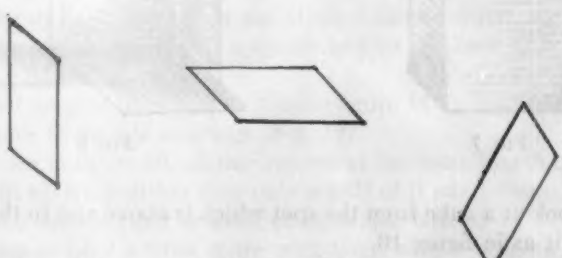


FIG. 2

Now let us study the same box if the top of it is open. In this case to figure 5 we add portions of the sides which are in the back and can be seen. With some shading we bring out the impression of the box (Fig. 7).

The sides of a box may be other than squares; we still can use the same techniques. We call figure 6 and figure 7 perspectives of a box.

It is interesting to see how the box looks if we cut the two front sides of it and unfold them (Fig. 8).

Now let us study a cube in different positions. If we look at a cube from the spot which is above and to the right of it we see it as in figure

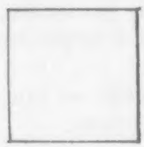


FIG. 3

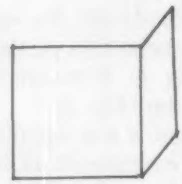


FIG. 4

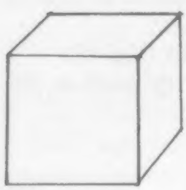


FIG. 5

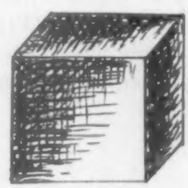


FIG. 6

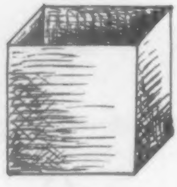


FIG. 7

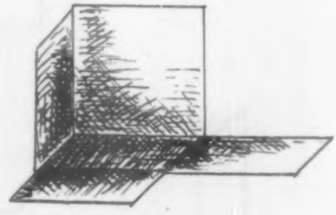


FIG. 8

9. If we look at a cube from the spot which is above and to the left of it we see it as in figure 10.

Can you tell where our position is with respect to the cubes in figures 11, 12, 13, 14, 15, and 16?

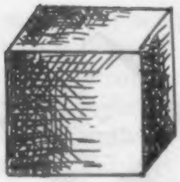


Fig. 9

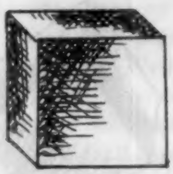


Fig. 10

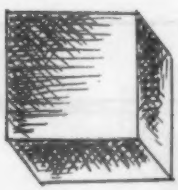


Fig. 11

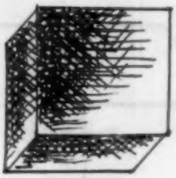


Fig. 12

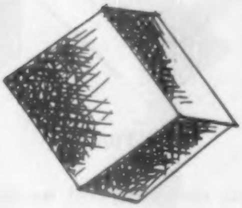


Fig. 13

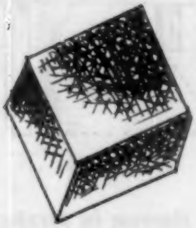


Fig. 14

Now let us have a little fun and study a simple object, say a simple table. The top of the table is a square and we can look at it so that it looks like figure 17.

Now let us give thickness to it as in figure 18.

To figure 18 we add four legs (Fig. 19).

As we see in figure 19, all the legs are of the same length but one of them is in such a position that only a part of it can be seen.

Can you draw a chair or some other simple object?

Now let us play a little more with these simple objects. Can you describe the two rectangles put together in figure 20? What about describing figure 21? How are the three pieces put together?

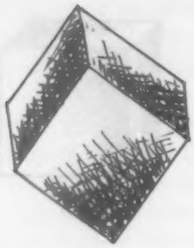


FIG. 15

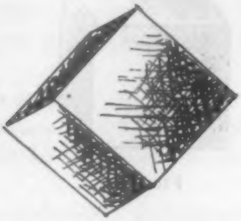


FIG. 16

FIG. 17

FIG. 18

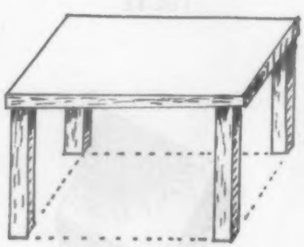


FIG. 19

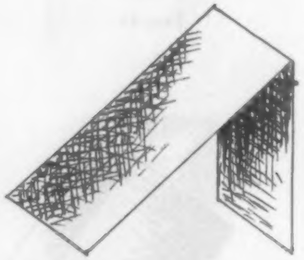


FIG. 20

2. *A theorem in perspective:* To create more interest we shall demonstrate a geometric interpretation of

$$(a+b)^3=a^3+3a^2b+3ab^2+b^3.$$

First we put together three squares of side $a+b$ (Fig. 22). This is actually a cube of volume $(a+b)^3$ where three sides of it have been cut off. It will be easier to explain the idea if we make the objects with pieces of cardboard and compare the drawings with them. Now let us fit a cube of side a, i.e., of volume a^3 in figure 22 (Fig. 23).

Then we fit 3 parallelepipeds each with volume a^2b next to a^3 (Fig. 24).

Now we add the 3 parallelpipeds of volume ab^2 to it (Fig. 25).

Finally we add a cube of volume b^3 to it (Fig. 26).

3. *Lines and Planes:* Here we would like to draw a few figures to demonstrate the positions of lines and planes with respect to one another.

It is universally accepted that a plane is represented by a portion of it which is bounded by a rectangle (see Fig. 2). In perspective a right angle does not necessarily look like a right angle. We shall show a line perpendicular to a plane by a figure (Fig. 27) where *d* is a line perpendicular to the plane *P*. A famous theorem of solid geometry is: Any plane containing *d* is perpendicular to *P*. We shall show a plane containing *d* in one figure and several planes containing *d* in another figure (Fig. 28).

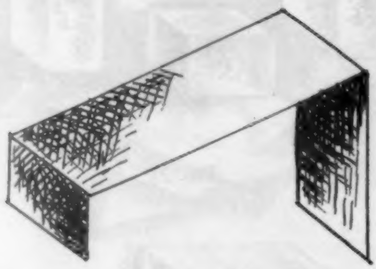


FIG. 21

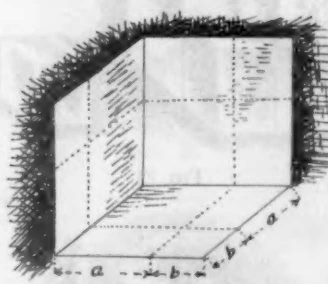


FIG. 22

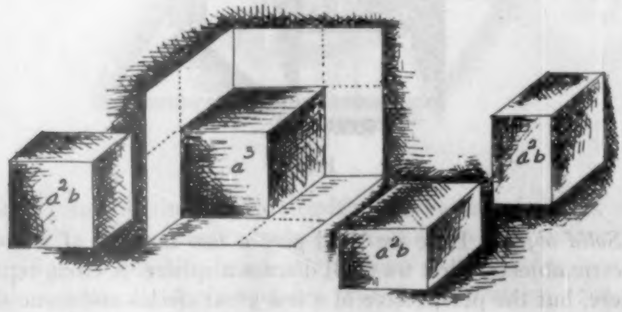


FIG. 23

The reader is expected to draw more complicated figures containing many planes and lines.

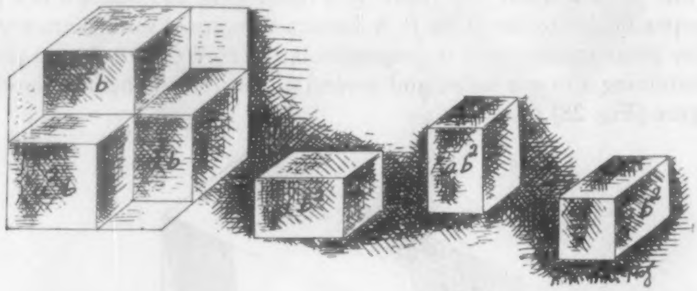


FIG. 24

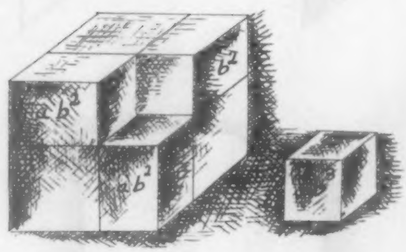


FIG. 25

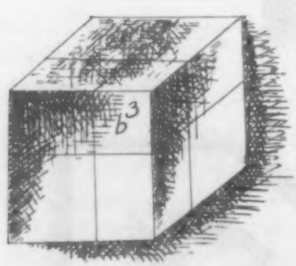


FIG. 26

4. *Solid objects:* Here we shall give a few samples of well-known geometric objects. First we shall discuss a sphere. A circle represents a sphere, but the perspective of a few great circles and some shading will bring out the impression of sphere (Fig. 29).

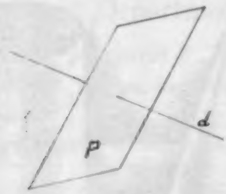


Fig. 27

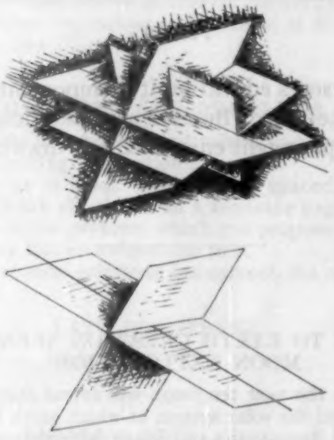


Fig. 28

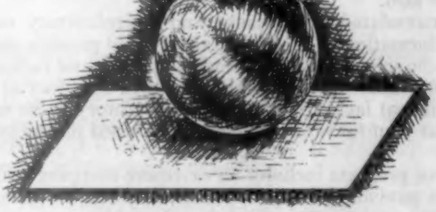


Fig. 29

We shall conclude the discussion with impressions of a right circular cone and a right circular cylinder. A circle in perspective looks like an ellipse. Thus the bases of the cone and cylinder look like ellipses and with slight shading we give the impression of a solid figure (Fig. 30).

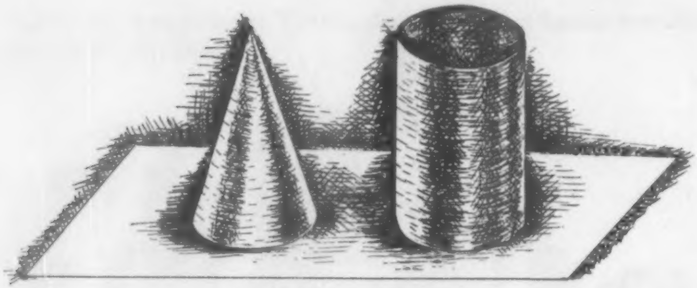


Fig. 30

As a part of a person's education it is important to have some exercise on realistic sketching. Besides mathematicians, scientists and engineers, other people might enjoy realistic drawing too.

CLUE TO EARTH CREATION SEEN IN MOON EXPLORATION

Lunar exploration in the next ten years will reveal the age-old secret of the creation of the earth and the solar system of which earth is a part, Dr. Robert Jastrow of the National Aeronautics and Space Administration predicted.

A successful orbit of a lunar satellite will yield information about the moon that scientists now can only guess at.

The solid and inert character of the moon has allowed it to collect on its surface "a record of its history that probably extends back through many billions of years to the earliest period of its infancy and to the beginning of the solar system," Dr. Jastrow said.

Moon dust, accumulated from cosmic and interplanetary sources since the early days of the formation of the moon, also "could provide clues to the origin of physical life in the solar system." Chemical analysis and radioactive dating on samples taken from lunar dust, estimated as much as a foot or more in depth, should reveal significant facts about the chemical history of the solar system.

NASA's ten-year plan for lunar exploration is based primarily on these scientific objectives.

The lunar science program includes an extensive mapping and analysis of the moon's surface to provide information that could affect navigation of lunar satellites and future projects for manned exploration; unmanned scientific observatories, capable of monitoring solar weather and interplanetary properties for a period of several years; and a study of the surface and interior of the moon by instrumented satellites placed on the moon and returned to earth by remote control.

Considerable work already has been done on mapping the moon. Actual lunar exploration is scheduled to begin, probably within the next two years, with the delivery of simple instrument packages to the vicinity and surface of the moon. These will provide preliminary information of the surface structure, surface radioactivity and level of seismic activity.

Problem Department

Conducted by Margaret F. Willerding

San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve her readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the test form will be used.

LATE SOLUTIONS

729. *G. P. Speck, Virginia, Minn.*

2753, 2758. *Mary Pat Brown, Chicago, Ill.*

2756, 2758. *C. W. Trigg, Los Angeles, Calif.*

2756, 2758. *J. Byers King, Denton, Md.*

2759. *Taken from "More Problematical Recreations."*

If each of the letters A, B, and C represents a particular digit, what is the minimum value of the whole number ABC divided by $A+B+C$? (The answer is not 1.)

Comment by C. W. Trigg, Los Angeles City College

It was shown in the solution to 2740 (SCHOOL SCIENCE AND MATHEMATICS, 61, 65, January 1961) that the minimum value is $10\frac{1}{19}$.

We now inquire into the maximum value of $ABC/(A+B+C)$. This will be obtained when $A>B>C$, A is large and $A+B+C$ is relatively small. Thus the maximum value sought is $910/(9+1+0)$ or 91.

2761. *Proposed by C. W. Trigg, Los Angeles City College*

TRITONE is divisible by 3 and by 7. Furthermore $T+RIT=ONE$. Find the digits uniquely represented by the letters in the decimal scale.

Solutions by H. R. Leifer, Pittsburgh, Pa.

From $T+RIT=ONE$, it is immediately apparent that $T+T=10+E$, $I+1=10+N$, and $R+1=0$. Obviously $I=9$, $N=0$, $5<T<9$, and $R\neq 8, 9$.

Since TRITONE is divisible by 3, the sum of its digits is divisible by 3. Using the values given above the sum of the digits is readily found to be $11+2E+2R$. Using the only possible values for T: 6, 7, 8, we readily find E: 2, 4, 6, and

R: 3, 1, 2 respectively. Checking the three possible restorations 6396402, 7197204, and 8298306 for divisibility by 7, we find that only the second meets this requirement and that the digits uniquely represented by the letters are $T=7$, $R=1$, $I=9$, $O=2$, $N=0$, and $E=4$.

Solutions were also submitted by W. B. Arnold, Victoria, B. C., Canada; George Cunningham, N. H. State Dept. of Ed.; Felix John, Philadelphia, Pa.; Sarane R. Loeb, Chicago, Ill.; Bernard T. Pleimann, Gardena, Calif.; and the proposer.

2762. *Proposed by Floyd D. Wilder, Bethany, Okla.*

If $y=x!$ where $x!$ is defined for all values of x by the gamma function, find dy/dx.

Solution by Dale Woods, Kirkville, Mo.

Since

$$y=x!=\Gamma(x+1)=\int_0^\infty t^x e^{-t}dt \quad \text{and} \quad \Gamma(x+1)$$

is continuous for all values of x except negative integers we have

$$dy/dx=\int_0^\infty \frac{\partial(t^x e^{-t})}{\partial x}\,dt=\int_0^\infty t^{x-1}(\log t)e^{-t}dt.$$

2763. *Proposed by Cecil B. Read, Wichita, Kans.*

Let aa, aaa, represent numbers expressed in decimal notation; i.e., for $a=7$, aa is seventy-seven, not 7×7, and $aaa=777$, not 7^3. For $a=9$,

$$999<99^9<9^{99}<9^{9^9}$$

but for $a=2$,

$$222<22^2<2^{22}<2^{2^2}.$$

Determine other than by trial and error, the least value of a for which

$$aaa<aa^a<a^{aa}<a^{a^a}.$$

Generalize to a number system with base k.

Solution by H. R. Leifer, Pittsburgh, Pa.

If $aaa<aa^a<a^{aa}<a^{a^a}$, then for base k,

$$ak^2+ak+a<(ak+a)^a<a^{ak+a}<a^{a^a}.$$

Since

$$a^{ak+a}<a^{a^a},\ ak+a<a^a, \quad \text{and} \quad (k+1)<a^{a-1}. \qquad (2<a<k).$$

Then

$$k+1<a^k, \quad (k+1)^a<a^{ak}, \quad a^a(k+1)^a<a^a a^{ak},$$

and

$$(ak+a)^a<a^{ak+a}.$$

Also

$$(ak+a)^a=a^a(k+1)^a=a^a\left[k^a+ak^{a-1}+\frac{a(a-1)k^{a-2}}{2!}+\cdots\right],$$

and since $2<a<k$,

$$a<a^a, \quad k^2<k^a, \quad k<ak^{a-1}. \quad 1<\frac{a(a-1)k^{a-2}}{2!},$$

then

$$a(k^2+k+1)<(ak+a)^a.$$

Thus for base k we need find the smallest a such that

$$a^{a-1}>k+1.$$

For base 10, this is readily seen to be 4 and

$$444<44^4<4^{44}<4^{4^4}.$$

2764. *Proposed by Brother Felix John, Philadelphia, Pa.*

There are three numbers in geometrical progression such that three times the first, twice the second, and once the third, taken in order form an arithmetical series; and also the first, the second increased by 8, and the third, taken in order, form an arithmetical series. What are the numbers?

Solution by Sister M. Lucine F.S.S.J., Hamburg, N. Y.

Let a, ar, ar^2 represent the three numbers in the geometrical progression. From the problem,

$3a$, $2ar$, and ar^2, taken in order form an arithmetical series; similarly, a, $ar+8$, and ar^2, also form an arithmetical series. Hence,

$$2ar-3a=ar^2-2ar \quad \text{while} \quad ar+8-a=ar^2-(ar+8)$$

From the two equations,

$$a=\frac{8}{r-1} \quad \text{and} \quad r=\frac{8+a}{a}$$

Since a is the first number, then $8+a$, is the second number and

$$\frac{64+16a+a^2}{a}$$

is the third number.

In the arithmetical series, the numbers are:

$$3a,\ 16+2a,\ \frac{64+16a+a^2}{a} \quad \text{and} \quad 16+2a-3a=\frac{64+16a+a^2}{a}-(16+2a)$$

from which a is 4. Since

$$r=\frac{8+a}{a},$$

then numerically r is 3. Therefore in the geometrical progression,

$$a \text{ is } 4; \quad ar \text{ is } 12; \quad ar^2 \text{ is } 36$$

The numbers in the first arithmetical series are: 12, 24, and 36.

The numbers in the second arithmetical series are: 4, 20, and 36.

Solutions were also submitted by W. B. Arnold, Victoria, B. C.; Canada; Sister Rose Christina, Tampa, Fla.; H. R. Leifer, Pittsburgh, Pa.; J. H. Means, Austin, Texas; Bernard T. Pleimann, Gardena, Calif.; C. W. Trigg, Los Angeles, Calif.; Brother Benedict Virgil, New Orleans, La.; Dale Woods, Kirksville, Mo.; Herbert Wolf, Chicago, Ill.; and the proposer.

2765. *Proposed by Howard D. Grossman, New York, N. Y.*

Given

$$a+b+c=1; \quad a^2+b^2+c^2=2; \quad a^3+b^3+c^3=3.$$

Find

$$a^4+b^4+c^4.$$

Solution by C. W. Trigg, Los Angeles City College

$$(a+b+c)^2=a^2+b^2+c^2+2ab+2bc+2ca$$

so

$$2(ab+bc+ca)=1-2=-1,$$

and

$$4[a^2b^2+b^2c^2+c^2a^2+2abc(a+b+c)]=1.$$

Then

$$a^4+b^4+c^4=(a+b+c)^4-\{4(a^3b+ab^3+b^3c+bc^3+c^3a+ca^3)$$
$$+6[a^2b^2+b^2c^2+c^2a^2+2abc(a+b+c)]\}.$$

Whereupon

$$-3(a^4+b^4+c^4)=1-[4(a^3+b^3+c^3)(a+b+c)+6/4]$$
$$=1-[12+3/2]$$

Therefore

$$a^4+b^4+c^4=25/6.$$

Solutions were also offered by W. B. Arnold, Victoria, B. C., Canada; George Cunningham, Concord, N. H.; Charles T. Salkind, Brooklyn, N. Y.; Herbert Wold, Chicago, Ill.; and the proposer.

2766. *Taken from Mathematical Pie*

Find the fallacy in: If $N>n$, $\log N>\log n$, $\frac{1}{2}>\frac{1}{4}$; therefore $\log\frac{1}{2}>\log\frac{1}{4}$; therefore $\log\frac{1}{2}>\log(\frac{1}{2})^2$; therefore $\log\frac{1}{2}>2(\log\frac{1}{2})$. Therefore $1>2$.

Solution by Brother Benedict Virgil, F.S.C., New Orleans, La.

In the first place, there is a typographical error in the section above which read: $\log\frac{1}{2}>\log(\frac{1}{4})^2$, but due to the rest of the problem, this could not have been intended.

For the fallacy in the solution, in the last step:

$$\log\tfrac{1}{2}<0$$

and according to the axioms of inequality, if unequals are divided by negative equals, the quotients are unequal in the opposite order. Therefore, the conclusion should read: Therefore $1<2$.

Solutions were also offered by W. B. Arnold, Victoria, B. C., Canada; Brother Felix John, Philadelphia, Pa.; H. R. Leifer, Pittsburgh, Pa.; J. H. Means, Austin, Texas; Bernard Pleimann, Gardena, Calif.; and Dale Woods, Kirksville, Mo.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

For this issue the Honor Roll appears below.

2761. *Mary Mathys, Visitation High School, Chicago, Ill.*

2764. *Galen L. Mueller, Clovis High School, Clovis, Calif.*

2764. *Floyd D. Wilder, Bethany Nazarene College, Bethany, Okla.*

PROBLEMS FOR SOLUTION

2785. *Proposed by G. P. Speck, Geneseo, N. Y.*

Without the use of tables, determine which is greater e^π or π^e.

2786. *Proposed by George S. Cunningham, Concord, N. H.*

What are the smallest non-negative distinct integers such that the difference of the cubes of two integers is precisely equal to the difference of the cubes of the other two integers?

2787. *Proposed by Enoch J. Haga, Turlock, Calif.*

A gentleman, who was about to begin a tour of Europe, worked out a secret code with his banker which he intended to use in case he should find himself short of funds. After some weeks, the banker received this wire from Europe: SEND. The gentleman, hearing nothing from his banker, sent another wire in a few days which read MORE. The banker, remembering the code, sent this reply: MONEY. The gentleman was relieved when shortly after he received the needed funds. How much did he receive?
(EDITOR'S NOTE: This is a new twist to a very ancient problem!)

2788. *Proposed by Donald R. Byrkit, West Chicago, Ill.*

In an ordinary deck of cards prove or disprove that the odds in favor of a four suit hand in seven random cards are almost the same as the odds against a four suit hand in six random cards.

2789. *Proposed by David Wiley, San Diego, Calif.*

Does

$$\sum_{n=1}^{\infty} \frac{1}{n^{1+1/n}}$$

converge?

2790. *Proposed by C. W. Trigg, Los Angeles City College*

A circle of radius r_1 is inscribed in an angle, the distance of its center from the vertex of the angle being d. A second circle, with a smaller radius r_2 is drawn tangent to the first circle and to sides of the angle. (a) Find an expression for r in terms of r_1 and d. (b) Test the result by summing the diameters of the circle

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Books and Teaching Aids Received

Astronomy

PLANETS, STARS, AND GALAXIES, by Stuart J. Inglis. Cloth. 14×20.5 cm. Pages x+474. 1961. John Wiley & Sons, Inc. 440 Fourth Ave., New York 16, N. Y. Price $6.75.

Biology, College

MILESTONES IN MICROBIOLOGY, by Thomas D. Brock. Cloth. 14.5×21 cm. Pages v+275. 1961. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, Price $3.95.

TAXONOMY OF FLOWERING PLANTS, by C. L. Porter, *University of Wyoming.* Cloth. 14.5×21.5 cm. Pages xii+452. 1961. W. H. Freeman and Company, 660 Market St. San Francisco 4, Calif. Price $6.75.

INTRODUCTORY BOTANY, by Arthur Cronquist. Cloth. 16×21 cm. Pages ix+892. 1961. Harper & Brothers Publishers, 49 E. 33rd Street, New York 16, N. Y.

Chemistry, College

GENERAL COLLEGE CHEMISTRY, by Charles William Keenan and Jesse Hermon Wood, both of *The University of Tennessee.* Cloth. 15.5×21 cm. Pages viii +750. 1961. Harper & Brothers Publishers, 49 East 33rd Street, New York 16, N. Y. Price $3.25.

Chemistry, Secondary

CHEMISTRY, by Alfred B. Garrett, John S. Richardson, and Arthur S. Kiefer. Cloth. 16×21 cm. vii+678 pages. 1961. Ginn and Company, Statler Building, Boston 17, Mass. Price $5.60.

Mathematics, College

COLLEGE ALGEBRA, by Adele Leonardy. Cloth. 14.5×21 cm. Pages xvi+440. 1961. John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $5.95.

INTRODUCTORY ALGEBRA, by Milton D. Eulenberg and Theodore S. Sunko. Cloth. 13×20 cm. 1961. John Wiley & Sons, Inc. 440 Fourth Ave., New York 16, N. Y. Price $4.95.

ELEMENTARY ALGEBRA FOR COLLEGE STUDENTS, by Irving Drooyan and William Wooton. Cloth. 14×20.5 cm. Pages x+272. 1961. John Wiley & Sons, Inc. 440 Fourth Avenue, New York 26, N. Y. Price $4.95.

THE CALCULUS OF FINITE DIFFERENCES, by George Boole. Paper. 12.5×18.5 cm. Pages xii+336. 1961. Chelsea Publishing Company, 50 E. Fordham Rd., New York 68, N. Y. Price $1.39.

ELEMENTS OF LINEAR ALGEBRA, by Lowell J. Paige and J. Dean Swift. Cloth. 15×21.5 cm. Pages xvi+348. Ginn and Company, Statler Building, Boston 17, Mass. Price $7.25.

SIMPLIFIED CALCULUS, by F. D. Westwater. Cloth. 12×17.5 cm. Pages viii +160. 1961. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $3.50.

BASIC MATHEMATICS, VOLUME I, by Norman H. Crowhurst. Paper. 21×14.5 cm. 152 pages. 1961. John F. Rider Publisher, Inc., 116 W. 14th Street, New York 11, N. Y. Price $3.90.

Mathematics, Secondary

A COURSE IN GEOMETRY, by Arthur W. Weeks and Jackson B. Adkins, *The Phillips Exeter Academy, Exeter, New Hampshire.* Cloth. 14.5×21.5 cm. Pages vii+552. 1961. Ginn and Company, Statler Building, Boston, Massachusetts. Price $4.40.

GEOMETRY, by W. H. E. Bentley, *Kilburn Grammer School,* and E. W. Maynard Potts, *Hendon Grammer School.* 11.5×18 cm. 112 pages. Price $1.32. Cloth. 1961. Ginn and Company, Statler Building, Boston 17, Massachusetts.

SENIOR TECHNICAL MATHEMATICS, by A. H. Heywood. Cloth. 12.5×17.5 cm. Pages xii+557. 1961. St. Martin's Press, 175 Fifth Ave., New York 10, N. Y. Price $4.50.

MATHEMATICS IN PRACTICE, by Arthur E. Brown, *Danforth Technical School, Toronto,* David E. Bridge, *Department of Labor, Federal Government,* and Wallace J. Morrison, *Danforth Technical School, Toronto.* Cloth. 14.5×22.5 cm. Pages xi+418. 1961. St. Matin's Press, 175 Fifth Ave., New York 10, N. Y. Price $3.10.

ALGEBRA IN EASY STEPS WITH MODERN UNITS, by Edwin I. Stein, *Leeds Junior High School Philadelphia*. Cloth. 19×25 cm. Pages vi+302+74. 1961. D. Van Nostrand Company, Inc., 120 Alexander Street, Princeton, New Jersey. Price $3.96.

Mathematics, Miscellaneous

FUN WITH MATHEMATICS, by Jerome S. Meyer. Paper. 9.5×16.5 cm. Pages viii+176. 1961. Fawcett Publications, Inc. Fawcett Building, Greenwich, Connecticut. Price $.50.

AN INTRODUCTION TO THE CUISENAIRE RODS, by William P. Hull. Paper. 14.5 ×21 cm. 20 pages. 1961. National Council of Independent Schools, 84 State Street, Boston 9, Mass.

HANDBUCH DER SCHULMATHEMATIK, by Herausgeber. Cloth. 23×15.5 cm. 296 pages.

STUDII SI CERETARI MATEMATICE. Pages 211–462.

REVUE DE MATHEMATIQUES PURES ET APPLIQUEES Page 287–525. Both paper. Both 15.5×22 cm. Both $2.23. Editura Academie Republicii Populare Romine.

TERNARY SYSTEMS, by G. Masing. Paper. 12.5×20 cm. 173 pages. 1961. Dover Publications, Inc., 180 Varick Street, New York 14, N. Y. Price $1.45.

Physics, College

THE NEW AGE IN PHYSICS, by Professor Sir Harrie Massey, *University of London*. Cloth. 13.5×19.5 cm. 342 pages. 1961. Harper & Brothers Publishers, 49 East 33rd St. New York 16, N. Y. Price $5.00.

SEMICONDUCTORS AND TRANSISTORS, by Alexander Schure. Paper. 19.5×13 cm. 144 pages. 1961. John F. Rider Publishers, Inc., 116 West 14th Street, New York 11, N. Y. Price $2.90.

ALTERNATING CURRENT ELECTRICITY, by Alexander Efron. Paper. 19.5×13 cm. 104 pages. 1961. John F. Rider Publisher, Inc., 116 W. 14th Street, New York 11, N. Y. Price $2.25.

BASIC TRANSISTORS, by A. Schure. Paper. 14×20.5 cm. 152 pages. 1961. John F. Rider Publisher, Inc., 116 14th Street, New York 11, N. Y. Price $3.95.

Science, Elementary

COMMON NATIVE ANIMALS, by M. F. Vessel and E. J. Harrington, *San Jose State College*. Paper. 18.5×26 cm. 175 pages. 1961. Chandler Publishing Company, Inc., 660 Market Street, San Francisco 4, California. Price $2.95.

HEATH SCIENCE SERIES. All cloth. All 16×21 cm. 1961. D. C. Heath, 285 Columbus Ave., Boston, Mass.

Book One.	153 pages.	Price $2.44.
Book Two.	210 pages.	Price $2.68.
Book Three.	282 pages.	Price $2.92.
Book Four.	282 pages.	Price $3.08.
Book Five.	330 pages.	Price $3.16.
Book Six.	362 pages.	Price $3.32.

ATOMS FOR JUNIORS, by Lew Landin. Cloth. 16×21 cm. 31 pages. 1961. Melmont Publisher, 5629 Melrose Ave., Los Angeles 38, Calif. Price $2.50.

ABOUT SILKWORMS AND SILK, by Sophie Wormser. Cloth. 16×21 cm. 31 pages. 1961. Melmont Publisher, 5629 Melrose_Ave., Los Angeles 38, Calif. Price $2.50.

ABOUT THE BIGGEST SALMON, by Will Hayes, Cloth. 16×21 cm. 31 pages. 1961. Melmont Publishers, 5629 Melrose Ave., Los Angeles 38, Calif. Price $2.50.

Science, Secondary

SCIENCE IN THE SPACE AGE, Book 7 by Herman and Nina Schneider. Both Cloth. Both 16×23 cm. $3.44. 361 pages.

SCIENCE AND YOUR FUTURE, Book 8. By Herman and Nina Schneider. 1961. 402 pages. $3.72. D. C. Heath. 285 Columbus Ave., Boston, Mass.

SCIENCE FOR THE SPACE AGE, by Victor C. Smith and B. Bernarr Vance. Cloth. 16×21.5 cm. Pages viii+616. 1961. J. B. Lippincott Company, 34 Beacon St., Philadelphia, Penn.

HEALTH AND SAFETY FOR YOU, by Harold S. Diehl, Anita D. Laton, and Franklin C. Vaughn. Cloth. xii+531 pages. 14.5×22 cm. 1961. McGraw-Hill Book Company, 330 W. 42nd Street, New York, New York.

GENERAL PHYSICAL SCIENCE, by George G. Mallinson, Jacqueline B. Mallinson, and Richard F. Welch. Cloth. 15.5×23 cm. Pages xii+628. 1961. McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y. Price $5.84.

Science, Miscellaneous

SCIENCE AND EDUCATION SERIES

SCIENCE AND EDUCATION. A policy statement issued by The Science Masters' Association and The Association of Women Science Teachers. Paper. 13×20 cm. 12 pages. 1961.

CHEMISTRY FOR GRAMMAR SCHOOL. Paper. 13×20 cm. 39 pages. 1961.
BIOLOGY FOR GRAMMER SCHOOLS. Paper 13×20 cm. 24 pages. 1961.
PHYSICS FOR GRAMMAR SCHOOLS. Paper 13×20 cm. 39 pages. 1961.
All published by John Murray, London, England.

THE FOREST AND THE SEA, by Marston Bates. Paper. 9.5×17 cm. 216 pages. 1961. New American Library of World Literature, Inc., 501 Madison Avenue, New York 22, N. Y. Price $.50.

ANNUAL REPORT OF THE SMITHSONIAN INSTITUTION 1959. 13.5×21 cm. Pages x+693. 1960. United States Government Printing Office, Washington, D. C.

QUALITY SCIENCE. Cloth. 13.5×21.5 cm. 210 pages. 1961. National Science Teachers Association, 1201 Sixteenth Street, N.W., Washington, D. C.

Miscellaneous

WILLIAM CHANDLER BAGLEY, by I. L. Kandel. Cloth. 20×12.5 cm. Pages xii+131. 1961. Bureau of Publications, Teachers College, Columbia University. Price $3.50.

THE STORY OF ALCHEMY AND EARLY CHEMISTRY, by John Maxson Stillman. Paper. 12.5×19 cm. xiii+565 pages. 1961. Dover Publications, Inc. 180 Varick Street New York 14, N. Y. Price $2.45.

THE AMERICAN OF GEORGE ADE, by Jean Shepherd. Cloth. 13.5×19.5 cm. 284 pages. 1961. G. P. Putnam's Sons, 200 Madison Ave., New York, New York. Price $4.00.

DICTIONARY OF MECHANICAL ENGINEERING, by Alfred Del Vecchio. Cloth. 346 pages. 15×22 cm. 1961. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $6.00.

Book Reviews

GENERAL PHYSICAL SCIENCE, by George G. Mallinson, Jacqueline B. Mallinson, and Richard F. Welch. Cloth. 15.5×23 cm. xii+628 pages. 1961. McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y. Price $5.84.

General Physical Science presents an entirely new approach in high-school general physical science. The textbook is designed to emphasize the knowledge and use of matter and energy resources by man, rather than being organized around the areas of geology, astronomy, chemistry and physics as generally treated in a course of this kind. This new organization is illustrated by an examination of the units into which the book is divided. Unit I includes an introduction to physical science and the tools used in measurement. Units II, III and IV assess the matter and energy resources of the universe. Together they cover the general characteristics of the universe, matter and energy in the universe, the place of the earth among the galaxies, the formation of the earth, and the earth in its present state. Also these units deal with the small bodies of the universe, chemical reactions, the earth and its energy supply, and the transformation and conservation of energy. Units V, VI and VII deal with the use of matter in its natural state, a discussion of the matter resources that require refining and processing, and the production and use of synthetics. Units VIII, IX and X cover energy from the viewpoints of energy that man does not control, energy that is partially controlled, and the control and application of mechanical energy, electrical energy, heat and light.

There are several special features included in *General Physical Science*. One feature, "Using Mathematics in Science," consists of sample problems set apart from the text material in the area being considered. The student should find this innovation helpful, since the problems are listed by page number in the Table of Contents.

Another feature, "Progress of Science," presents recent advances in science. The features are also listed by page number in the Table of Contents. All tables of data in the book are listed by page number as "Scientific Data." There is also a list of filmstrips produced by the publisher specifically for use with this textbook. There is an abundance of end-of-chapter activities which include many well-selected aids for review and further study.

The book is among the most attractive high-school science textbooks ever published. Color is used widely and wisely throughout the book. It is apparent that much time was devoted to the selection of appropriate up-to-date illustrations. An example of this may be seen in the end papers, consisting of Laue X-ray photographs of beryl. The diagrams are also well done and appropriate to the area being considered. An example of this, as well as of the use of analogy, may be found on page 501 in the study of series and parallel electrical circuit. Here, the authors compare the filling of a football stadium having three gates through which the crowd must pass in succession to a series circuit, and the filling of a stadium having three separate gates used at the same time to a parallel circuit. The legends of both diagrams and illustrations are written to extend the text and make the reader think.

Some may believe that mathematics is not used as extensively as it might be. However, it should be pointed out that this textbook is written for use in a course in high school general physical science that is to serve two functions, namely, to provide a general background for those students who will not major in science, and to provide a background in physical science for those students who will later take courses in physics and chemistry. This textbook will serve both functions well.

It is the opinion of this reviewer that this is an excellent textbook for use in the course for which it is intended. There are, of course, several minor typographical errors of the type always found in the first printing of a book. However, none of these is serious.

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FOOD CHEMISTRY, by Lillian Hoagland Meyer, *Professor and Head, Department of Chemistry, Western Michigan University, Kalamazoo, Michigan.* Cloth. 269 pages. 15×23 cm. 1960. Reinhold Publishing Corporation, 403 Park Avenue, New York 22, New York. $6.75.

The author of this text has had many years of successful experience in the teaching of general and applied chemistry to students of home economics. Furthermore, she is the author of a widely used textbook, *Introductory Chemistry*, which was especially planned for college students of home economics and of nursing. It is only natural that out of this background of experience one finds her writing a book entitled, *Food Chemistry.* In the preface, the author states: "It is the author's belief that an attempt to consolidate the fundamentals of food chemistry with recent advances in the food industry is now appropriate. Although there have been splendid books available for many years in the area of food analysis and more lately in food technology, we have not had one that unifies these areas with basic chemistry in a simple fashion. The present book is designed to meet this need. It is intended primarily as a text in food chemistry for undergraduate students in home economics, food technology, and chemistry. However it should be useful also as a reference book for students and research workers in these fields."

The reviewer believes that the author has accomplished her objective in a satisfactory manner. He further believes that the simplicity of style and clarity of statement should make the information easily understood by students who have only a limited background in chemistry.

The topics considered are: Chapter One, Development of Food Chemistry; Chapter Two through Four treats Fats, Carbohydrates and Proteins as they are found in foods. General subjects considered in these chapters are: properties, industrial processing, characteristic reactions, and importance in diet. Also included are: Chapter Five, The Flavor and Aroma of Food; Chapter Six, Meat and Meat Products; Chapter Seven, Vegetables and Fruits; Chapter Eight, Milk and Milk Products; Chapter Nine, Cereals and Their Use; Chapter Ten, Food Additives.

At the end of each chapter is found a good list of journal and source book references. Also following the final chapter is an appendix on food additives.

The publishers are to be complimented on the type of paper used, on the readability of the print, and on the general make up of the book.

The reviewer further believes that many high school and college teachers will want this book on their private shelf as a source book of valuable information.

GERALD OSBORN
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A BOOK OF TONGUES, by Anne Welsh Guy. Cloth. 48 pages. 25×16 cm. 1960. The Steck Company, Austin, Texas, $1.75.

The author, in this book, points up the differences in structure and functions of tongues. More than twenty different kinds of animals are illustrated along with a brief discussion of the purposes which the tongue serves for each of these animals.

The illustrations are in two color and attractive. The text is appropriate from the stand point of vocabulary and content for the age level. For the most part it is accurate and written in an interesting way.

In general the book is well suited for upper primary or lower elementary grade levels and would be a worth while addition to a science enrichment library.

Although the reviewer freely recommends the book for its good qualities it is recognized that some criticism is justified. It is anthropomorphic—that is likes,

dislikes, and purpose is ascribed to the animals. The discussion of the fish tongue might lead one to feel that the text is over simplified in some areas. Some question might also arise concerning the text about snakes—the implication that all snakes are harmless, since the tongue is used only as a feeler, might be unwise.

ILLA PODENDORF
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PHYSICS, developed by The Physical Science Study Committee of Educational Services Incorporated. Cloth. 18×25.5 cm. 656 pages. D. C. Heath and Company, Boston, Massachusetts. Price $5.48.

This textbook is the product of four years of work by the Physical Science Study Committee. This much publicized committee was formed to develop an improved introductory physics course.

The book is the first truly "modern" physics textbook to be published. The approach is different than that usually found in a high school physics course. This could cause some difficulty for teachers using the textbook for the first time. However, both teachers and students will find the book interesting.

The book is divided into four parts. Part I is an introduction to the fundamental physical concepts of time, space, and matter. Part II is a treatment of optics and waves. Part III deals with the topics usually covered in mechanics. Part IV includes the areas of electricity and atomic structure. In all cases emphasis is placed on fundamental concepts rather than facts.

The textbook presupposes a rather adequate background in algebra as well as trigonometry. This will be an obstacle to many students of average ability. Many of the topics presented are difficult for most students and will require a great deal of time. This, and the fact that the textbook contains a great deal of material will probably make deletion of some topics necessary.

The textbook is well illustrated and the diagrams are well done. The use of more color in illustrations probably would have made the book more attractive.

Whether the new course will be accepted universally can only be determined by trial and time but the approach used will certainly have an influence in changing the existing inadequate high school and college physics courses.

It is the opinion of this reviewer that this is an excellent textbook. Any physics teacher dissatisfied with the present high school physics course should certainly consider this challenging new book for adoption.

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